LOS ALAMOS NATIONAL LABORATORY
2002 POLLUTION PREVENTION ROADMAP

by

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This Roadmap is certified, along with the 1997 Site Pollution Prevention Plan (LA-UR-97-1726), to satisfy the requirements of 40CFR264.73(b)(9) (RCRA).

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ACRONYM AND ABBREVIATION LIST

AT	Applied Technologies (Group)
BUS	Business Operations (Division)
C	Chemistry (Division)
C-ACS	Chemistry Division, Analytical Chemistry Sciences Group
C-ACT	Chemistry Division, Actinide Chemistry Group
CCF	Central Computing Facility
CFR	Code of Federal Regulations
C-INC	Isotope and Nuclear Chemistry Group in the Chemistry Division
CMR	Chemistry and Metallurgy Research (Facility)
County	Los Alamos County
County Landfill	The DOE-Owned, Los-Alamos-County-Operated Landfill
CTWC	Cooling Tower Water Conservation
CY	Calendar Year
D&D	Decontamination and Decommissioning
DARHT	Dual Axis Radiographic Hydrotest (Hydrodynamics Testing Facility)
DOE	Department of Energy
DOE/DP	Department of Energy/Defense Programs
DOE/EM	Department of Energy/Environmental Management
DOT	Department of Transportation
DP	Defense Programs
DSSI	Diversified Scientific Services, Inc.
DVRS	Decontamination and Volume Reduction System
DX	Dynamic Experimentation (Division)
EES	Earth and Environmental Science (Division)
EM	Environmental Management
EMS	Environmental Management System
EO	Executive Order
EPA	Environmental Protection Agency
ER	Environmental Restoration
ESA	Engineering Sciences and Applications (Division)
ESH	Environment, Safety, and Health (Division)
ESO	Environmental Stewardship Office
FFCO/STP	Federal Facility Compliance Order/Site Treatment Plan
FWO	Facility and Waste Operations (Division)
FWO/UI	Facility and Waste Operations/Utilities and Infrastructure Group
FY	Fiscal Year
GDMS	Gas Discharge Mass Spectrometer
GIC	Green Is Clean
GSAF	Generator Set-Aside Fee
GW	Ground Water

ACRONYM AND ABBREVIATION LIST (cont)

HE	High Explosives
HEPA	High-Efficiency Particulate Air
HLW	High-Level Waste
ISM	Integrated Safety Management
ISM-E	Environmental Component of ISM
JCNNM	Johnson Controls Northern New Mexico
JIT	Just In Time
Laboratory	Los Alamos National Laboratory
Landfill	The DOE-Owned, Los-Alamos-County-Operated Landfill
LANSCE	Los Alamos Neutron Science Center Experiment, or Los Alamos Neutron Science Center (Division)
LAPP	Los Alamos Power Pool
LDCC	Laboratory Data Communications Center
LEDA	Low-Energy Demonstration Accelerator
LIR	Laboratory Implementation Requirement
LLW	Low-Level (Radioactive) Waste
M	Mixed
MBA	Material Balance Area
MLLW	Mixed Low-Level Waste
MRF	Material Recovery Facility
MT	Metric Ton
MTRU	Mixed Transuranic
NARS	Nitric Acid Recovery System
NDA	Nondestructive Assay
NMED	New Mexico Environment Department
NMT	Nuclear Materials Technology (Division)
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
ODS	Ozone-Depleting Substances
P2/E2	Pollution Prevention and Energy Efficiency
PCB	Polychlorinated Biphenyl
PETN	Pentaerythritol Tetranitrate
PP	Prevention Program (Office)
PPE	Personnel Protective Equipment
PVA	Polyvinyl Alcohol
PVC	Polyvinyl Chloride
R&D	Research and Development
RANT	Radioassay and Nondestructive Testing
RCA	Radiological Control Area
RCRA	Resource Conservation and Recovery Act
RFP	Request for Proposal
RLWTF	Radioactive Liquid Waste Treatment Facility
RRES	Risk Reduction and Environmental Stewardship (Division)

ACRONYM AND ABBREVIATION LIST (cont)

SAR	Safety and Analysis Report
SCC	Strategic Computing Complex
SNM	Special Nuclear Material
STL	Safeguards Termination Limit
SWB	Standard Waste Box
SWEIS	Sitewide Environmental Impact Statement
SWO	Solid Waste Operation
SWS	Sanitary Wastewater System
SWSC	Sanitary Wastewater Systems Consolidation
TA	Technical Area
TCE	Trichloroethylene
TCLP	Toxic Characteristic Leaching Procedure
TFCH	Treated Formerly Characteristic Hazardous (Waste)
TRI	Toxic Release Inventory
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
UC	University of California
WAC	Waste Acceptance Criteria
WCRRF	Waste Compaction, Reduction, and Repackaging Facility
WFM	Waste Facilities Management
WIPP	Waste Isolation Pilot Plant
WMM	Weapon Materials and Manufacturing
WTA	Western Technical Area

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EXECUTIVE SUMMARY

Los Alamos National Laboratory's (the Laboratory's) goal is to experience zero environmental incidents. The Pollution Prevention (PP) Office in the Risk Reduction and Environmental Stewardship Division, which manages the Laboratory's Pollution Prevention Program, coordinates efforts to eliminate the sources of environmental incidents. The PP Office assists the Laboratory in eliminating these sources through waste minimization, pollution prevention, and conservation improvements. In fact, good environmental practices move the Laboratory beyond compliance-based goals toward zero waste produced, zero pollutants released, zero natural resources wasted, and zero natural resources damaged. These practices and policies help the Laboratory operate in such a way that future employees will have equal or better natural resources and quality of environment than do current employees.

Pollution prevention and environmental stewardship not only protect the environment; they also pay for themselves by reducing costs and creating a safer workplace. Furthermore, they minimize both waste- and pollution-related work tasks, enabling staff to devote more time to mission activities. In effect, they increase productivity. Environmental awareness, good environmental practices, and reducing the sources of environmental incidents are the responsibility of every person working at the site.

This roadmap documents the Laboratory's Pollution Prevention Program and the process used to define and implement environmental improvements. It describes current operations, improvements that will eliminate the sources of environmental incidents, and the end state that is the Laboratory's goal. Over the next 18 months, the Laboratory will move from an environmental management approach that emphasizes compliance requirements to an Environmental Management System that embodies the concepts of ISO 14001. The Laboratory currently has implemented environmental protection as part of Integrated Safety Management (ISM) implementation. The initial implementation focuses on ensuring that Laboratory operations comply with applicable laws and regulations. The ISM Program requires continuous improvement of the ISM System. An ISM environmental upgrade is now being planned.

This 2002 version of the roadmap is responsive to the pollution prevention and environmental efficiency goals issued by the Secretary of Energy on November 12, 1999; it is also certified to satisfy the waste minimization program documentation requirements of 40 CFR 264.73(b)(9) (Resource Conservation and Recovery Act).

LOS ALAMOS NATIONAL LABORATORY
2002 POLLUTION PREVENTION ROADMAP

1.0. INTRODUCTION

1.1. Site Description

Los Alamos National Laboratory (the Laboratory) occupies 43 square miles of land in northern New Mexico and is located within the county of Los Alamos, ~35 miles northwest of Santa Fe. The Laboratory is divided into 50 technical areas (TAs), with locations and spacing that reflect historical development patterns, topography, and functional relationships. Owned by the Department of Energy (DOE), the Laboratory has been managed by the University of California (UC) since 1943.

Los Alamos is located in a temperate mountain climate at an elevation of ~7400 ft. In July, the warmest month of the year, the temperature ranges from an average daily high of 27.2°C (81°F) to an average daily low of 12.8°C (55°F). In January, the coldest month, the temperature ranges from an average daily high of 4.4°C (40°F) to an average daily low of -8.3°C (17°F). The large range in daily temperatures results from the relatively dry, clear atmosphere, which allows strong solar heating during the day and rapid radiative cooling at night. The average annual precipitation (rainfall plus the water equivalent of frozen precipitation) is 18.7 in.

Topographically, the Laboratory is situated on a series of mesas separated by canyons. Most of the natural water and aqueous discharges from Laboratory operations flow into and along the canyon floors.

1.2. Laboratory Mission

The central mission of the Laboratory is to enhance the security of nuclear weapons and nuclear materials worldwide. Its statutory responsibility is the stewardship and management of the nuclear stockpile. This requires a solid foundation in science and state-of-the-art technology. The Laboratory has approximately 7740 UC employees plus approximately 3300 contractor personnel. Partnering with universities and industry is critical to the Laboratory's success. Carefully selected civilian research and development programs complement the Laboratory's mission.

As in any other activity, waste and pollution are generated in executing the Laboratory's mission. Environmental management at the Laboratory provides for the reduction and elimination of this waste and pollution and for remediation of sites impacted by previous operations. Figure 1-1 shows the Laboratory process map, which is an environmental systems view of the Laboratory from the local environmental perspective. Not shown, but also important, is the regional environmental impact related to Laboratory operations.

The Laboratory receives funding and mission assignments from the DOE. Through the DOE, it also performs work for other government sponsors and private industry. To accomplish these assignments, the Laboratory procures services, materials, equipment,

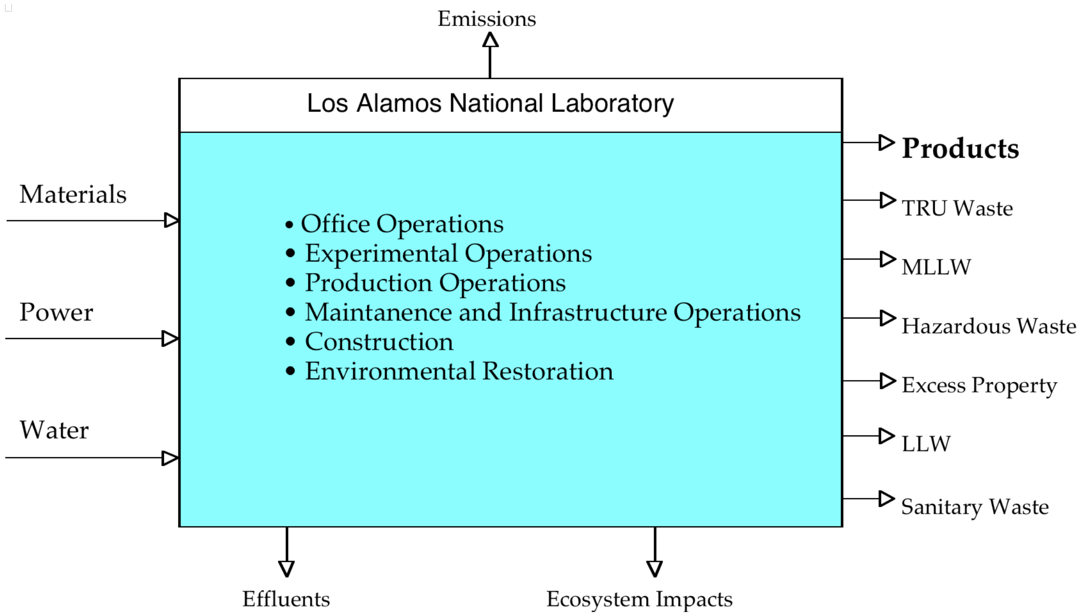


Fig. 1-1. Laboratory process map.

new facilities, and commodities (electricity and natural gas). The Laboratory also takes in water from the regional aquifer and air from the surrounding atmosphere. Figure 1-1 shows the substance and energy inflows to the Laboratory. The inflows are used in the six types of operations provided in the figure and in the following list.

1. Office operations use the most UC and subcontractor person-hours.

2. Experimental operations include bench-scale research, experiments at the Los Alamos Neutron Science Center (LANSCE), criticality experiments at TA-18, explosive tests at Dynamic Experimentation (DX) Division firing sites, and fabrication of the experimental hardware used in experiments.

3. Production operations include Nuclear Materials Technology (NMT) Division's plutonium processing and production operations. They also include NMT's analytic chemistry operations at the Chemistry and Metallurgy Research (CMR) Facility.

4. Maintenance and infrastructure operations include all Johnson Controls Northern New Mexico (JCNNM) maintenance activities, Facility Management Unit maintenance activities, and sitewide infrastructure systems such as the solid waste operation (SWO) (TA-54), Radioactive Liquid Waste Treatment Facility (RLWTF) (TA-50) power plant, Sanitary Wastewater Systems (SWS) wastewater plant, water influent system, and highway system.

5. Construction includes both smaller construction projects performed by JCNNM and major construction projects conducted by competitively selected contractors.

6. Environmental Restoration (ER) includes all DOE/Environmental Management (EM)-funded facility Decontamination and Decommissioning (D&D) and contaminated-site remediation.

Because the Laboratory's products are mostly information oriented, most material inflows become byproduct or waste outflows. Consequently, both consumption and waste generation reflect the Laboratory's inefficiency. Outflows are divided into transuranic (TRU) waste, mixed (M) low-level (radioactive) waste (LLW), LLW, hazardous waste, and solid sanitary waste. These outflows are well defined and are discussed in detail later in this document. Excess property includes all items processed through the Business Operations Division (BUS)-6/JCNNM salvage system. Effluents include all of the wastewater released from the site into the canyons. Two-thirds of the water brought on site is discharged through outfalls; the remainder evaporates. Emissions include greenhouse gases, criteria gases, and process off-gases.

1.3. Pollution Prevention in Integrated Safety Management

The Laboratory's primary environmental-excellence goal is zero environmental incidents. The strategy for achieving this goal has two primary elements:

1. The Laboratory will comply with all applicable environmental laws, regulations, DOE orders, and consensus standards identified through the Laboratory's Integrated Safety Management (ISM) Work Smart Standards process and listed in the UC contract. Compliance is managed through the ISM System. The Environment, Safety, and Health (ESH) Division assists Laboratory divisions in planning and maintaining compliant operations.

2. The Laboratory will continue to execute a prevention-based program that seeks to eliminate the potential for environmental incidents. Both compliance and pollution prevention are accomplished through the ISM system.

The control and reduction of waste generated by the Laboratory must take place within certain constraints. Pollution-prevention and waste-minimization activities must not compromise safety or increase worker exposure to radioactive or hazardous materials. For that reason, pollution prevention is an integral part of ISM. To help accomplish pollution prevention, the Laboratory evaluates environmental hazards.

The environmental component of ISM (ISM-E) identifies all of the Laboratory's activities, products, and services that can interact with the environment; evaluates each with regard to its magnitude and severity; and prioritizes them accordingly. Options and business cases can be developed to mitigate the highest priority aspects. In this way, the environmental aspects of Laboratory operation can be managed efficiently and cost effectively to protect the environment. Pollution prevention and waste management also should not compromise either productivity or product quality. Indeed, successful implementation of good pollution-prevention practices should increase both productivity and quality because waste is a manifestation of inefficiency.

Executive Order (EO) 13148 requires each DOE site to have developed an Environmental Management System (EMS) by fiscal year (FY)05. The requirements for the EMS are specified in the EO and in subsequent documents. When pollution-prevention strategies are fully developed and incorporated into the ISM, the resulting system will satisfy the requirements for an EMS as defined in EO 13148.

1.4. Pollution-Prevention Goals

On November 12, 1999, the Secretary of Energy issued challenging pollution-prevention and energy efficiency (P2/E2) leadership goals to achieve his environmental mission at DOE sites. On February 8, 2001, the Laboratory submitted a plan to meet the secretarial P2/E2 leadership goals and described the resource requirements necessary to accomplish that plan. In that plan, the Laboratory proposed to adopt goals that were responsive to the secretarial goals but that differed from specific secretarial goals in some cases because of local circumstances. This section describes the rationale for the proposed goals and the metric the Laboratory has adopted for measuring progress toward the goals.

The Laboratory's response to the secretarial goals is captured in the waste-minimization performance measures for FY02. The measures and associated metrics for all waste types are presented in Table 1-1. The weights listed in this table, with the exception of toxic release inventory (TRI) chemical weights, are in units of metric tons (MT or tonnes). The metric ton is the standard unit used by the DOE and is used throughout this document to express weight. Laboratory performance toward the goals will be measured through an index that combines performance toward individual goals into a single index number expressed as a percentage. A 0 index corresponds to baseline year performance; a 100 corresponds to achieving the 2005 goal. The performance metrics are based on the weighted average of the index based on the nine individual goals in this measure. All nine goals are weighted equally.

1.5. The Prevention Program

The Prevention Program (PP) Office was established to integrate pollution-prevention and waste minimization activities across the Laboratory. Recently, the PP Office adopted a new strategy for providing this integrating function. Before FY02, the PP, then called the Environmental Stewardship Office (ESO), maintained a centralized staff to support and integrate pollution-prevention and waste minimization activities at the Laboratory. Waste generation at the Laboratory has decreased dramatically in the last few years as a result of the ESO activities. Because of this decreased waste generation, levels are now low enough to allow individual divisions to assume responsibility for their own pollution-prevention activities. As a result, the PP has adopted a strategy of identifying pollution-prevention coordinators in each of the major generating divisions, delegating prevention responsibilities to these coordinators, and integrating the Laboratory-wide prevention activities through them. This strategy has the significant advantage of placing the primary responsibility for pollution prevention in the very organizations where waste generation is taking place.

1.6. Roadmap Methodology

The approach that the PP Office has taken to prevent pollution and minimize waste relies on an understanding of the systems that produce waste. A system is defined as an aggregation of related processes that have a common product or purpose and can be regarded as the highest-level process. Thus, the Laboratory is viewed as a system comprising the various processes depicted in Fig. 1-1. That figure is a typical system or top-level process map. Each of the high-level processes identified in the map can, in turn, be deconstructed to describe individual processes that produce waste. Normally, several distinct waste streams are identified with each process or activity. The waste stream then can be quantified with respect to size. In most cases, the largest waste streams are the best candidates for minimization. Sometimes regulatory, policy, or cost requirements make smaller streams the better candidates for minimization. Pareto analysis is the tool most often used to evaluate the relative importance of waste streams. When the streams have been identified, quantified, and evaluated, specific actions can be defined to reduce the waste in the most important streams. Process mapping is the technique used to define specific actions. These individual actions are integrated into action plans for each waste type.

Process maps are constructed by specifying a set of inputs or influxes of materials; a description of activities required to produce the desired product; and a set of outputs, one of which is waste. In a typical process map, the input to the system, all the processes involved in producing the product, and all the pathways to the final output are described graphically. By closely examining and quantifying each process step and, if necessary, generating lower-level process maps, it is possible to see the details of waste production. When the inputs, activities, costs, and outputs are understood and quantified, the root causes of waste generation can be assessed for that process and the

TABLE 1-1
WASTE MINIMIZATION GOALS AND INDEX-WEIGHTED PERFORMANCE METRICS

Routine Waste Minimization	2005 Goal Reduction	Baseline	FY05 Goal	FY02 Performance	Index
Hazardous Waste Reduction	90%	307 mt	31 mt	16 mt	100%
Low- Level Waste Reduction	80%	1987 m^3	397 m^3	372 m^3	100%
Mixed- Low- Level Waste Reduction	80%	12.3 m^3	2.5 m^3	5.5 m^3	74%
TRI Chemical Use Reduction	90%	88,293 lb	8829 lb	28,872 lb	75%
Sanitary Waste Reduction	50%	2780 mt	1390 mt	1822 mt	79%
Sanitary Material Recycling	45%	N/A	45%	75%	100%
Cleanup/Stabilization Waste Reduction	10%	N/A	10%	20%	100%
Affirmative Procurement	N/A	N/A	100%	99%	99%
Replace ODS* Class I Chillers	100%	3000 tons	3000 tons	510 tons	17%
TRU Waste Minimization	50%	100 m^3	50 m^3	87 m^3	24%

*Ozone-depleting substance.

points in the process where opportunities to reduce waste may exist can be identified. After those points are identified, waste-reduction strategies can be developed for each process. The result is an action plan for waste minimization. This process is used by the PP Office to develop programs and projects to reduce waste in the Laboratory's major waste streams.

1.7. Roadmap Structure

This current roadmap document describes the Laboratory's principal waste streams; the source, volume, and root cause of the waste; and programs and projects designed to avoid or minimize the waste. The roadmap contains eight chapters; one chapter is an introduction, five chapters (Chapters 2 through 6) are devoted to the major individual waste streams, and two chapters (Chapters 7 and 8) describe conservation programs at the Laboratory.

The chapter for each waste type contains a definition of that waste type, the regulatory drivers associated with that waste type, an analysis of the waste streams that make up the waste type, and a description of the programs and projects (both current and proposed) that are intended to avoid or minimize the waste.

The analysis section in each chapter contains a systems-based process analysis of the data reported for that waste type. That analysis frequently is supplemented by results of other analysis techniques, such as the Green Zia analysis.

Each waste-type chapter contains a section at the end that details performance metrics for that waste type. The metric is based on progress toward implementing the projects identified as important to reducing the large waste streams within that waste type. Full implementation earns three points; partial implementation earns fewer points. In some cases, implementation is not the project goal, in which case the goal is detailed in the comments section. These metrics will be used to manage progress against objectives during the year.

The roadmap serves several purposes. Its primary purposes are to report pollution-prevention and waste-minimization performance, update analyses of waste streams, and periodically revisit and evaluate the programs and projects intended to reduce the environmental impact of Laboratory operations. The roadmap also serves to satisfy the requirements of 40CFR264.73(b)(9) in the Resource Conservation and Recovery Act (RCRA). In addition, the roadmap serves as the DOE-mandated description of the Laboratory's sitewide pollution-prevention plan. Additional information regarding the Laboratory's environmental impact can be found in the following documents.

1.8. General Data on the Environmental Impact of Laboratory Operations

- United States Department of Energy, "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory," United States Department of Energy document DOE/EIS-0238 (January 1999).

- United States Department of Energy, "Mitigation Action Plan for the Site-Wide Environmental Impact Statement for Continued Operation of the Los

Alamos National Laboratory," United States Department of Energy document DOE/EIS-0238 (September 1999).

- "Environmental Surveillance at Los Alamos during 2000," Los Alamos National Laboratory document LA-13861 (October 2001).

The roadmap does not contain any information regarding effluents or outfalls, except those associated with water conservation projects. There is no information on air or TRI emissions. There are no data regarding sediments, groundwater, or site ecology. The roadmap contains no Laboratory fleet transportation efficiency data. These data may be found in the following documents.

1.9. Air Emissions, Sediments, Surface Water, Groundwater, and Site Ecology

- "Environmental Surveillance at Los Alamos during 2000," Los Alamos National Laboratory document LA-13861 (October 2001).
- "New Mexico 2.73 Emissions Inventory," Los Alamos National Laboratory document LA-13850-SR (August 2000).
- "US Department of Energy Report 2000 LANL Radionuclide Air Emissions," Los Alamos National Laboratory document LA-13839-ENV (August 2001).
- Water-quality database: http:/wqdbworld.lanl.gov.

1.10. National Pollutant Discharge Elimination System (NPDES)-Permitted Outfalls

- NPDES Permit Number NM0028355 Fact Sheet (December 1999) http://www.esh.lanl.gov/~esh18/.

1.11. Toxic Chemical Release Inventory

- "Toxic Chemical Release Inventory for the Emergency Planning and Community Right-to-Know Act," Los Alamos National Laboratory document LA-13868-PR (November 2001).

2.0. TRANSURANIC WASTE

2.1. Introduction

Transuranic (TRU) waste is waste containing >100 nCi of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 yr (atomic number greater than 92), except for (1) high-level waste (HLW); (2) waste that the Department of Energy (DOE) has determined, with the concurrence of the Administrator of the Environmental Protection Agency (EPA), does not need the degree of isolation required by Code of Federal Regulations 40 CFR 191; or (3) waste that the United States Nuclear Regulatory Commission (NRC) has approved for disposal on a case-by-case basis in accordance with 10 CFR 61. TRU waste is generated during research, development, nuclear weapons production, and spent nuclear fuel reprocessing.

TRU waste has radioactive elements such as plutonium, with lesser amounts of neptunium, americium, curium, and californium. These radionuclides generally decay by emitting alpha particles. TRU waste also contains radionuclides that emit gamma radiation, requiring it to be managed as either contact handled or remote handled. Approximately half of the TRU waste analyzed is mixed TRU (MTRU) waste, containing both radioactive elements and hazardous chemicals regulated under the Resource Conservation and Recovery Act (RCRA).

The total volume of TRU waste managed by the DOE—currently in inventory (storage) and projected through 2034—is estimated to be ~171,000 m^3. TRU waste is disposed of at the Waste Isolation Pilot Plant (WIPP), a geologic repository near Carlsbad, New Mexico.

TRU waste at the Laboratory can be classified as either legacy waste or newly generated waste. Legacy waste is that waste generated before September 30, 1998. DOE Environmental Management (DOE/EM) is responsible for disposing of this waste at WIPP and for all associated costs. Newly generated waste is defined as waste generated after September 30, 1998; DOE/Defense Programs (DOE/DP) is responsible for disposing of this waste at WIPP. This roadmap focuses only on the newly generated wastes. Within this broad category, newly generated wastes are subdivided further into solid and liquid wastes, as well as routine and nonroutine wastes. Solid wastes include cemented residues, combustible materials, noncombustible materials, and nonactinide metals. Liquid wastes comprise effluent solutions associated with the nitric acid and hydrochloric acid plutonium-processing streams. Because of the final pH of these streams, they are also referred to, and are reported as, the acid and caustic waste streams, respectively. Routine waste is defined as waste produced from any type of production operation, analytical and/or research and development (R&D) laboratory operations; treatment, storage, and disposition facility operations; "work for others"; or any other periodic and recurring work that is considered ongoing in nature.

Nonroutine is defined as one-time operations waste: wastes produced from environmental restoration program activities, including primary and secondary wastes associated with retrieval and remediation operations, legacy wastes, and decontamination and decommissioning (D&D)/transition operations. TRU and MTRU wastes are reported separately because of the differing characterization requirements applied to them. These requirements are detailed in the RCRA and the Federal Facilities Compliance Order/Site Treatment Plan (FFCO/STP). The top-level process map for TRU waste is shown in Fig. 2-1.

Most of the TRU wastes generated at the Laboratory are associated with the Stockpile Stewardship and Management Program, the MilliWatt Heat Source Program, and nuclear materials R&D. Nuclear Materials Technology (NMT) Division is the principal waste generator responsible for these programs, which are conducted at the Plutonium Facility [Technical Area (TA)-55-PF4] and the Chemistry and Metallurgy Research (CMR) Facility (TA-3, Building SM-29). The MilliWatt Heat Source Program is the primary producer of ^{238}Pu-contaminated TRU waste. A small quantity of TRU waste is produced from waste characterization activities required for waste disposal at WIPP. The Applied Technologies (AT) Group of the Risk Reduction and Environmental Stewardship (RRES) Division performs these characterization activities.

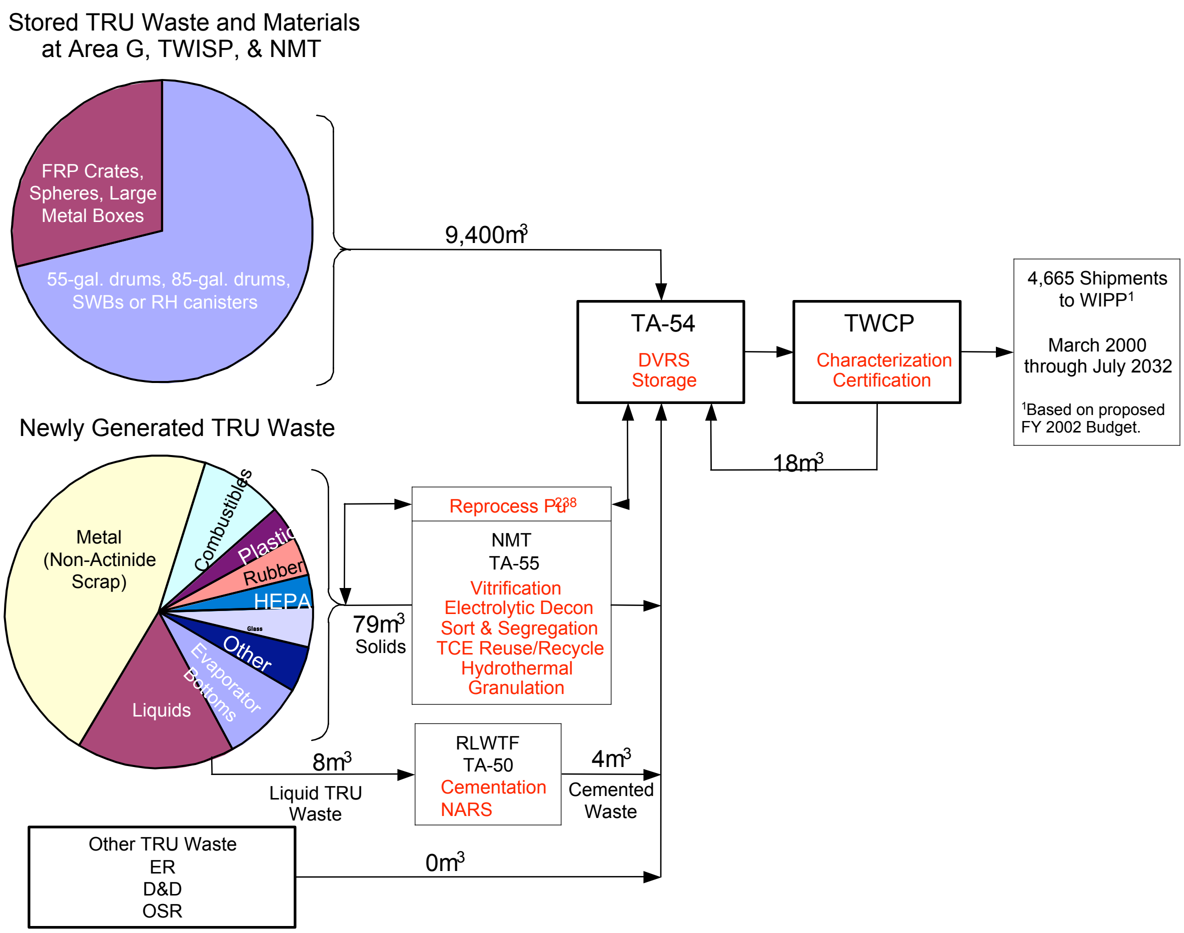


Figure 2-2 shows the total routine and nonroutine TRU and MTRU generated by organizations and by relative volume of waste generated. All of the RRES-AT TRU waste is nonroutine, and the Facility and Waste Operations (FWO) Division waste is solid waste generated from the treatment at the Radioactive Liquid Waste Treatment

Fig. 2-1. Top-level TRU waste process map and waste streams.

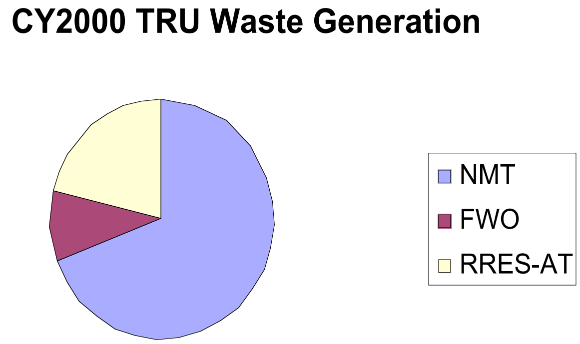


Fig. 2-2. TRU and MTRU waste generating organizations.

Facility (RLWTF) of the NMT Division acid and caustic waste streams. Fiscal-year (FY)00 data are used because the plutonium-processing facility saw limited operations in FY01 and because the RLWTF did not produce TRU waste in FY02.

The total volume of TRU waste generated by the Laboratory is shown in Fig. 2-3 and is identified as routine, nonroutine, and environmental remediation waste. The Environmental Remediation (ER)/D&D Program has produced TRU waste intermittently; this waste is related directly to the area or facility being remediated or decommissioned. In FY97, significant quantities were generated because of the D&D of TA-21, which was the old uranium- and plutonium-processing site. On March 16, 2000,

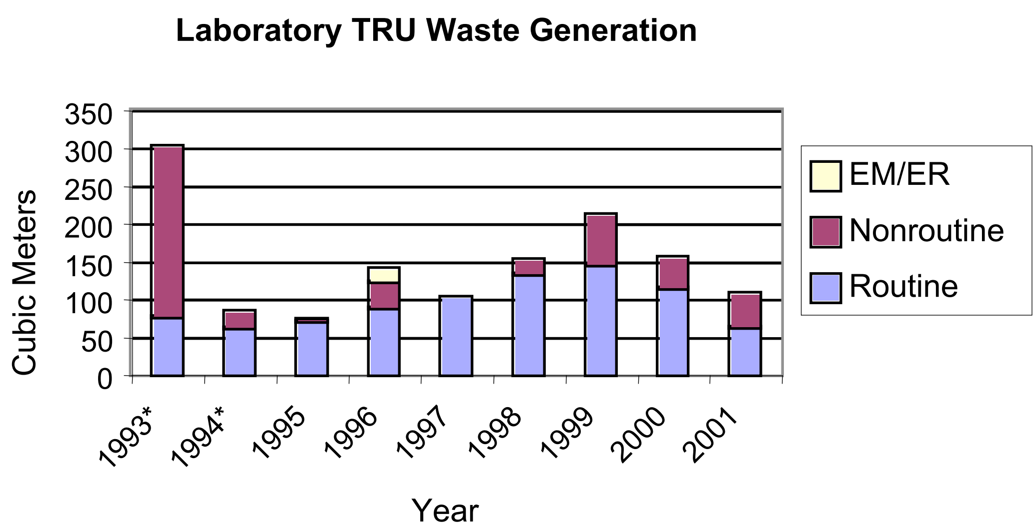


Fig. 2-3. Generation rates for TRU waste at the Laboratory.*

*All data are for FYs except 1993 and 1994. Data for 1993 to 1995 obtained from EM/ES: 96-350 letter of baseline corrections submitted to the DOE in December 1996. Data for 1996 to 1999 were obtained from previous reports to the DOE on waste generation and are stored in the "twilight.saic" database. Data for 2000 to 2001 were obtained from the solid-waste operation (SWO) database "swoon".

a radiological release of ^{238}Pu occurred near a glovebox in Los Alamos National Laboratory's (the Laboratory's) Plutonium Processing and Handling Facility (TA-55). As a result of the subsequent Type A Accident Investigation and the response to that investigation, work within TA-55 was curtailed for the remainder of FY00 and a portion of FY01. The curtailment of operations resulted in artificially low TRU waste generation rates for FY00 and FY01.

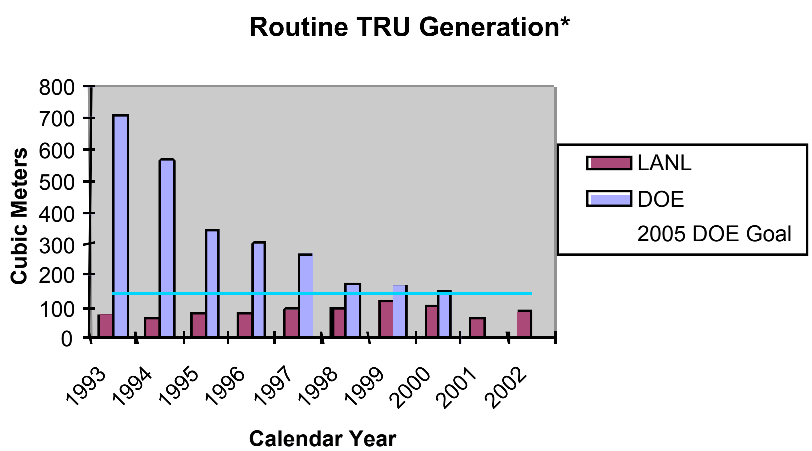
2.2. TRU Waste Minimization Performance

The DOE 2005 pollution prevention goals require that the DOE complex reduce "routine" TRU/MTRU waste generation by 80% to <141 m^3 by 2005. The Laboratory's allocation of that 141 m^3 has not been determined but only the Laboratory and the Savannah River Site have ongoing missions related to the use of plutonium. However, the Laboratory must reduce its present generation rate if the DOE is to achieve that goal. Between 1993 and 1998, the amount of TRU waste generated by the Laboratory increased from 76.7 to 121.7 m^3 (58%). The volume of routine TRU waste produced by the Laboratory decreased in FY00 and FY01 as a result of unplanned shutdowns of the TA-55 Plutonium Processing Facility. To help achieve the DOE complex-wide goal, the Laboratory set an FY05 performance goal that includes decreasing routine TRU waste generation by 50% from a baseline of 100 m^3.

The recent trend in TRU/MTRU waste generation is shown in Fig. 2-4. The DOE goal shown is the 80% reduction from the calendar-year (CY)93 baseline. It is evident that the Laboratory will have to continue its aggressive waste avoidance and minimization measures to help the DOE meet that goal.

2.3. Waste Stream Analysis

TRU wastes are generated within radiological control areas (RCAs). These areas also are material balance areas (MBAs) used for security and safeguards to prevent the potential diversion of special nuclear material (SNM). TRU and MTRU wastes are reported



*The DOE 2001 and 2002 total volumes are not yet available from the DOE's Central Internet Database.

Fig. 2-4. TRU waste generation by CY.

separately because of the different characterization requirements for the wastes. These requirements are detailed in the RCRA and the FFCO/STP—New Mexico Environment Department (NMED), which stipulates treatment requirements for MTRU wastes. In CY99, WIPP received a “No Mitigation Variance,” which allows it to accept MTRU waste for disposal without treatment. However, the characterization requirements for MTRU waste remain. MTRU waste can be shipped to WIPP without treatment, except as needed to meet storage and transportation requirements. In the following sections, TRU/MTRU wastes will be discussed as one waste type because the waste minimization strategy for both waste types is the same. As shown in Fig. 2-5, MTRU waste is ~80% of the TRU waste stream. The use of acceptable knowledge for characterization of newly generated TRU waste at the TA-55 Plutonium Processing Facility may increase the percentage of MTRU.

The TA-55 Plutonium Facility processes ^{239}Pu from residues generated throughout the defense complex into pure plutonium feedstock. The manufacturing and research operations performed at TA-55 in the processing and purification of plutonium result in the production of plutonium-contaminated scrap and residues. These residues are processed to recover as much plutonium as is practical. These recovery operations, associated maintenance operations, and TA-55 plutonium research are the sources of TRU waste generated at TA-55.

TRU waste materials, process chemicals, equipment, supplies, and some RCRA materials are introduced into the RCAs in support of the programmatic mission. All SNM introduced into Building PF-4 at TA-55 is stored in the vault in the PF-4 basement until needed for processing. Because of the hazards inherent in the handling, processing, and manufacturing of plutonium materials, all process activities involving plutonium are conducted in gloveboxes. High levels of plutonium contamination can build up on the inside surfaces of gloveboxes and process equipment as a result of the process or because of leaking process equipment. All materials being removed from the gloveboxes must be multiple-packaged to prevent the spread of contamination outside the glovebox. Currently, all material removed from gloveboxes is considered to be TRU waste. Large quantities of waste, primarily solid combustible materials such as plastic bags, cheesecloth, and protective clothing, are generated as a result of contamination avoidance measures taken to protect workers, the facility, and the environment.

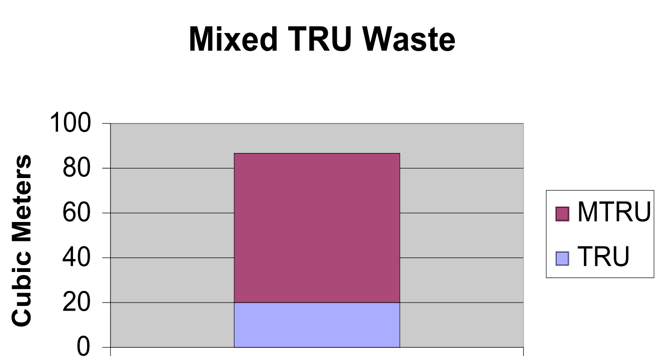


Fig. 2-5. The proportion of Laboratory-generated mixed TRU waste.

Process residues with plutonium contamination less than the safeguards termination limits (STLs) and cemented evaporator bottoms are other solid TRU wastes generated during operations. Process residues exceeding the STL values are returned to the vault for storage and future reprocessing. From FY98 through FY00, ~59,087 kg of solid TRU waste was generated by NMT Division. The percentage breakdown of that waste is shown in Fig. 2-6.

The TRU waste stream is the result of Laboratory missions focused on the Stockpile Stewardship and Management Program, the MilliWatt Heat Source Program, and nuclear materials R&D. NMT Division is the predominant generator of TRU wastes. In FY01, NMT Division prepared an integrated TRU Waste Minimization Management Plan that included project descriptions, required technologies, cost, cost savings, waste reduction estimates, and implementation issues for a comprehensive set of waste avoidance/minimization activities specific to NMT Division operations. The NMT Division philosophy and expectations for environmentally conscious plutonium processing are presented in the NMT Division Waste Management Program Plan. The goals of this plan are to reduce liquid waste by 90% and essentially to eliminate the combustible waste stream by CY03. Both plans made assumptions regarding annual funding levels and programmatic priorities and thus must be updated periodically.

NMT Division, E-ET, and FWO Waste Facilities Management (WFM) Group all generate TRU waste. Effective waste minimization must begin at TA-55 because the TRU waste produced at the TA-50 RLWTF is a direct result of treating TA-55 caustic and acid waste streams and because the E-ET TRU waste results from characterizing and certifying NMT-Division-produced waste (both legacy and newly generated).

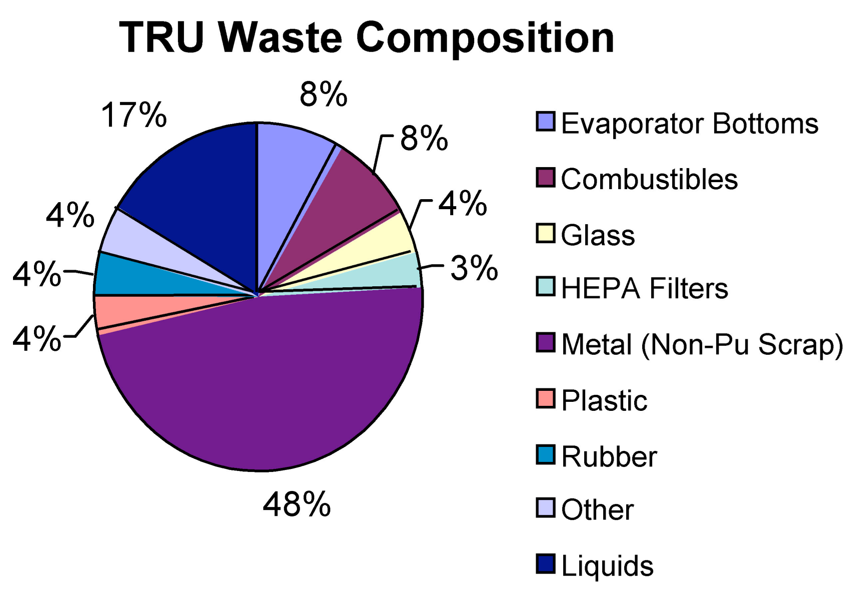


Fig. 2-6. Composition of TRU waste from NMT Division, FY98 through FY00.

Combustible Wastes (10 m^3). Combustible wastes comprise ~10% of the TRU waste generated at the Laboratory. For the MilliWatt Heat Source Program, combustible solids account for almost 90% of the TRU wastes contaminated with ^{238}Pu, for which there is currently no disposal pathway. In all instances, combustible waste comprises mostly plastic bags, plastic reagent bottles, plastic-sheet goods used for contamination barriers, cheesecloth, gloves, protective clothing worn by workers, and a small volume of organic chemicals and oils.

Noncombustible TRU Waste (20 m^3). Noncombustible TRU waste includes glass, high-efficiency particulate air (HEPA) filters, graphite, plastic, rubber, or other materials.

Nonactinide Metals (49 m^3). Nonactinide metals are any metallic waste constituents that may be contaminated with, but are not fabricated out of, actinide metals. Metallic wastes typically include tools, process equipment, glovebox structures, facility piping, and ventilation ducting. Significant volumes of metallic waste are generated under the following conditions: (1) when gloveboxes have reached the end of their useful life, (2) when processes within the facility and glovebox are changed, (3) when routine and nonroutine maintenance activities are completed, and (4) as facility construction projects are implemented to meet new programmatic missions.

Cemented Wastes (4 m^3). Cemented wastes are those acidic and caustic processing sludges and oxalate precipitation residues that contain levels of plutonium exceeding the STLs but containing less than the values requiring reprocessing. Before being discarded, the residues must be immobilized to minimize their potential attractiveness for diversion. Cementation meets this immobilization requirement. The high concentrations of actinides in this sludge frequently exceed the thermal wattage limit for WIPP disposal and require dilution by as much as a factor of five to meet certification requirements. Implementation of vitrification for this waste stream will reduce the final volume by a factor of four.

Caustic and Acidic Liquid Waste (8 m^3). Caustic liquid waste results from the final hydroxide precipitation step in the aqueous chloride process. Feedstocks for this process typically are anode heels, chloride salt residues, and other materials having a relatively high chloride content. Efforts are underway to upgrade the throughput capabilities of the aqueous chloride process to handle the increased quantities of chloride residues that will result from the workoff of legacy waste under the 94-1 Residue Stabilization Program. Over the next 3 to 5 years, throughput quantities are expected to double. Caustic process liquids are transferred to the TA-50 RLWTF for final processing via the caustic waste line. Acidic liquid waste is derived from processing plutonium feedstock with nitric acid for matrix dissolution. Following oxalate precipitation, the effluent is sent to the evaporator, where the overheads are removed and sent to the acid waste line for further processing. Evaporator bottom sludge is cemented into 55-gal. drums for disposal.

TRU solid wastes are accumulated, characterized, and assayed for accountability purposes at the generation site. TRU solid waste is packaged for disposal in metal 55-gal. drums, 4-x-4-x-6-ft standard waste boxes (SWBs), and oversized containers. Security and safeguards assay measurements are conducted on the containers for accountability before they are removed from PF-4. TRU wastes removed from PF-4 in 55-gal. drums and SWBs are shipped to TA-54, Area G for storage on the same day they are removed. Oversized containers of TRU waste are staged on an asphalt pad behind PF-4 and are shipped to TA-54 within 1 week of removal. Detailed characterization of

TRU wastes occurs at TA-54, Building 34, the Radioassay and Nondestructive Testing (RANT) Facility; and at TA-50, Building 69, the Waste Compaction, Reduction, and Repackaging Facility (WCRRF). Samples from drums are sent to the CMR building for characterization in some cases. TRU waste is stored at TA-54, Area G, until it is shipped to WIPP for final disposal. Certification of the waste for transport and disposal at WIPP is the responsibility of the Environmental Science and Waste Technology Group of E Division. TRU waste shipments to WIPP began on March 25, 1999, and are expected to continue through 2032.

Liquid TRU wastes from the nitric acid (acidic) and hydrochloric acid (caustic) aqueous processes are transferred from TA-55 to the TA-50 RLWTF via separate, double-encased transfer lines for processing and further removal of plutonium by flocculent precipitation. The precipitate is cemented into 55-gal. drums and transported to TA-54 for storage and ultimate disposal at WIPP as TRU solid waste. In FY00, ~11,660 L of liquid TRU waste was processed at the TA-50 RLWTF. Of this volume, 76% came from the acid waste stream and the remaining 24% from the caustic waste stream. Implementation of the Nitric Acid Recovery System (NARS) has reduced the volume of the acidic waste stream to the extent that the RLWTF did not produce TRU waste in FY02.

The cost for handling, storage, and disposal of TRU waste was estimated at ~$58,000/m^3 in FY01. However, that cost did not include the fixed cost of the storage facility at TA-54 or the cost to open and operate WIPP (fixed disposal cost).

2.4. Improvement Projects

Many process improvements have been identified for implementation within TA-55 and in the processing of TRU waste after it is produced. Priorities for new waste minimization projects and activities within TA-55 are detailed in the integrated TRU Waste Minimization Management Plan prepared by NMT Division in FY01. These projects are divided into three categories: (1) projects completed in the last year, (2) projects currently funded, and (3) ongoing and unfunded proposed projects. Projects are characterized further by type: source reduction (SR), sort and segregate (SS), reuse/recycle (RR), and treatment (T) or disposal (D). Most of the projects completed in previous years continue to avoid and minimize TRU waste.

2.4.1. Completed TRU Waste Minimization Projects

Nitric Acid Recovery System (NARS) (RR). The NARS was fully implemented in this past year. Additional transfer lines are being installed in PF-4 to make the recycled acid available to more users.

Decontamination and Volume Reduction System (DVRS) (T). The DVRS is designed for the decontamination and size reduction of oversized TRU waste items, including gloveboxes and process equipment. It consists of an outer building that provides secondary containment and storage and preparation space and an inner building that houses a shear-bailer volume reduction machine and provides segmented space for removal of packaging and decontamination of the waste materials. Currently, the DVRS processes TRU waste that is less than the Category 3 radiological limits (8.4 g of ^{239}Pu equivalent). When a safety and analysis report (SAR) is approved in approximately

2 years, the DVRS will become a Nuclear Category 3 facility and will be able to process waste with an inventory up to 900 g of ^{239}Pu equivalent.

2.4.2. Ongoing TRU Waste Minimization Projects

These projects have been funded and currently are being executed. These ongoing TRU waste minimization and avoidance projects are funded by the Prevention Program (PP) Office and GSAF programs and by operating funds.

Small Scale Granulator and Compactor for PF-4 TRU Waste (T). This project proposes to use *waste minimization* to reduce the volume of the current inventory of radioactive contaminated glass, organics, ceramics and tin by at least 60%. Over the last year, ESA-AET has been involved in studies that used a granulator to size reduce these items in a large scale process. With the space limitations at PF-4 and the focus on QUAL-1, a full-scale system (glove box, granulator, and a material transport system) clearly could not be integrated at TA-55 in a timely fashion. This project will extend the feasibility studies and knowledge gained over the past two years and focus on reducing the scale of the granulation process. This will ensure fast and safe deployment of a small and efficient granulation and compactor system into an existing glove box that will fit in the space allocated at TA-55. By implementing this technology within the next fiscal year, significant progress will be made toward the mandated 2005 goal of 80% reduction of TRU wastes

Vitrification System (T). The PP Office is funding the fabrication, testing, and installation of a vitrification process for the TRU waste that currently is solidified with cement. The project provides for the fabrication and installation of gloveboxes to house the vitrification equipment, fabricate and operationally test the vitrification system, and install the equipment within the gloveboxes in TA-55 PF-4. The Vitrification System will produce waste drums certifiable to WIPP waste acceptance criteria (WAC) and is expected to reduce the generation of TRU/MTRU cemented waste at a rate of 20 to 30 drums per year.

Gas Discharge Mass Spectrometer (GDMS) (SR). An in-line GDMS currently is under development and deployment. This analytical instrument allows real-time analyses of metal feeds and castings. It not only enhances the process efficiency in the plutonium foundry but also reduces the amount of samples sent off site for analyses, the waste generated, and the reprocessing cost. The use of an inline GDMS will reduce operational costs and drastically reduce the TRU waste that would be produced in the wet chemistry analysis of these samples.

Plutonium Oxidation State Diagnostic for Chloride Line (SR). This project is funded through the GSAF program and will implement a real-time, in-line capability to determine rapidly the state of plutonium oxidation while a batch is in process by monitoring the visible light absorption spectrum of plutonium in solution. This diagnostic will use off-the-shelf, compact, reliable spectrometers. By providing a continuous knowledge of the plutonium oxidation state, this diagnostic will enable operators to adjust process conditions immediately if the oxidation state drifts. This process will eliminate most of the unacceptable batches, thus reducing operation costs and process waste generation by 5% to 10%. It also will reduce the consumption of reagents for oxidation state adjustment, which are commonly overused to compensate for uncertainty about the oxidation state. The primary waste stream that will be affected consists of 15,000 L/yr of neutralized TRU liquid waste (4.3 mCi/L average) that normally is piped to TA-50 for precipitation and solid waste disposal as TRU waste. A 5% reduction in the number of batches would eliminate 750 L (3.2 Ci) of this stream per year.

PF-4 Trichloroethylene (TCE) Upgrade (RR). The processes for cleaning plutonium parts at T A-55 are being reviewed for a series of upgrades designed to reduce the amount of waste generated, reduce the exposure levels of the operator to both radiation and solvent, and aid in removing any inconsistencies in the level of cleaning. Central to these upgrades is the proposed replacement of the ultrasonic bath currently in use with a mechanical spray washer developed by the Weapons Component Technology Group, NMT-5. A second development designed to reduce the amount of waste generated further is the proposed installation of a distillation recycle unit in conjunction with a fluorometer and pH meter to monitor the organic contaminant loading and TCE breakdown. Combined, these process modifications will reduce the annual volume of TCE waste by >95%. This project is funded through the GSAF program.

Hydrothermal Processing of Organic Chemicals (T). This project is completing the upgrade and installation of a Hydrothermal Processing System used to destroy organic chemicals. Use of the Hydrothermal Processing System will reduce the generation of TRU/MTRU waste organic compounds by ~0.4 m^3/yr.

Ion Beam Etching and Polishing of Plutonium Alloys (SR). Plutonium-based alloys must be mounted and polished by conventional metallographic procedures, including diamond polishing until the surface of the specimen displays a mirror finish. After a final polish is achieved, the specimen surface is chemically treated or electrochemically etched to reveal surface features of interest. The ion etching system will replace much, if not all, of the diamond polishing and yield a finished, treated surface, with no additional processing. This will eliminate the chemical or electrochemical etching steps after polishing and the waste those steps produced.

2.4.3. Project Development and Unfunded Projects

These projects either have been proposed or are under development to help reduce mixed (M) low-level waste (LLW). Proposed projects that are currently unfunded and projects under development are designated as such.

Small Item Volume Reduction (T). The plutonium processing facility at TA-55, PF-4, generates metal tools, parts, and equipment. The DVRS was developed to process the large metal items such as gloveboxes. This project will demonstrate the volume reduction of waste containers filled with small metal tools, parts, and equipment at the DVRS.

Glove Improvement Project (SR). Glovebox gloves protect nuclear materials workers from radiological contamination. At the Laboratory, ~50 gloves fail and ~490 are replaced each year. The typical failure results in facility contamination, worker exposure/contamination, waste generation, and work stoppage. Implementation of this project will result in a 50% reduction in glove failures. As part of this project, a common glove procurement specification and glove testing protocol will be developed and implemented. A lead-free glove will be procured, tested, and implemented. A self-monitoring glove will be procured, tested, and implemented. A second glove source or vendor and a vendor quality assistance program will be established.

Radiolytically Induced Recombination of Hydrogen and Oxygen (SR, RR). Weapons-related activities at TA-55 produce TRU wastes that contain ^{238}Pu, ^{239}Pu, and ^{241}Am. High-wattage cemented TRU waste is more likely to generate hydrogen gas in concentrations that exceed the 5% lower-flammability limit for hydrogen imposed by the United States Department of Transportation (DOT) and the NRC. Drums are only partially filled so as not to exceed the prescribed wattage limit; partial filling results in the shipment of a greater number of waste drums. This proposal will establish a feasible means of maintaining a low percentage of hydrogen in the headspace of TRU waste drums by the effective use of the alpha-particle radioactivity in the waste. By selecting the proper geometric dimensions of a waste container, it may be possible to eliminate the hydrogen generation hazard. Successful use of the proposed packaging scheme for enhancing recombination of hydrogen and oxygen will reduce the number of drums loaded for shipment to the WIPP significantly. This project will fabricate three reaction chambers that will contain plutonium/americium-cemented waste forms or configurations to determine the effectiveness of recombination with and without headspace.

Hot-Water Extraction for Characterization of Hazardous Compounds (SR). The established methods for extraction and characterization of organic compounds were developed for nonradioactive wastes. When applied to TRU waste, those same methods were environmentally unfriendly, yielded poor analytical results, were expensive, exposed the analyst to radiological hazards, and produced an MTRU waste that currently has no path to disposal. The processes involving RCRA solvents will generate ~800 L of MTRU waste per year. This project will purchase off-the-shelf instrumentation to demonstrate the effectiveness of hot-water extraction (250°F water at a pressure of 1000 psi) for the characterization of hazardous compounds. Successful implementation of this project will (1) eliminate a source of MTRU waste, (2) reduce characterization time and improve quality, (3) greatly enhance worker safety, and (4) reduce operational costs.

Dissolution Chemistry (SR). The TA-55 Plutonium Facility processes ^{239}Pu from residues generated throughout the defense complex into pure plutonium feedstock. The manufacturing and research operations performed at TA-55 in the processing and purification of plutonium result in the production of plutonium-contaminated scrap and residues. The residues are processed to recover as much plutonium as practical, and the process step with the highest nuclear material loss is dissolution. Although the materials that are not completely dissolved are not lost, they are effectively trapped in a residue matrix that cannot be recovered or discarded and thus must be stored indefinitely. Dissolution chemistry has been examined in the past without identifying successful techniques or new technologies that would successfully integrate themselves into the nitrate-based process. This project would develop techniques to effectively dissolve contaminated materials to enhance the recovery of plutonium.

Solid Surface Leaching Testing (SR). This project would develop and implement sonication-aided surface leaching for decontamination of plutonium-contaminated materials. In addition to obtaining a better general understanding of dissolution chemistry, better solid surface leaching is needed, whether electrolytic (surface electrolytic decontamination or in baths) or sonic (sonication-aided leaching using proprietary surface penetration and wetting agents). This project includes conducting proof-of-principle experiments with a sonication system and the procurement and installation of sonication system equipment if the proof-of-principle activities are successful.

Polymer Filtration Equipment (SR, T). This project would engineer and implement polymer filtration on the caustic waste stream from TA-55. Although the effluent and filtrate losses in the caustic and acid waste streams are generally of low concentration, the large volumes involved result in a significant loss. Demonstrated technologies are available but still require engineering development to be deployed successfully. Polymer filtration for the caustic waste stream is one such technology. Reducing the concentration and volume of the caustic liquid waste stream will reduce the processing required at the RLWTF and the amount of TRU waste produced by the RLWTF.

Development of Extraction Chromatography (SR, T). This project would develop extraction chromatography for the nitric acid waste stream coming from TA-55. Although the effluent and filtrate losses in the caustic and acid waste streams are generally of low concentration, the large volumes involved result in a significant loss of nuclear material. Demonstrated technologies are available but still require engineering and development to deploy them successfully. One such technology is the use of extraction chromatography for acid solutions. Reducing the concentration and volume of the caustic and acid waste streams reduces the processing required at the RLWTF and the amount of TRU waste produced by the RLWTF.

Development and Certification of Destructive Chemical Analysis (SR). This project would implement advances in analytical chemistry and nondestructive assay (NDA) to improve process control and material accountability. To maintain good process control, a significant and integrated level of analytical chemistry is required. Because of the lack of radiation signature from some of the materials, NMT Division must rely on destructive chemical analysis using estimates of the isotopic composition for routine process control and material accountability. Advances in analytical chemistry and NDA make elemental destructive assay available (no reliance on isotopic input), as well as possible nondestructive solution assay advances that would be applicable to the material's isotopic makeup. Improvements in process controls will reduce the radioactive waste streams by reducing the amount of material requiring disposal and the concentration of radionuclides within the waste.

Pyrolysis of Plastics (SR, T). This project will develop and demonstrate the pyrolysis of contaminated plastic materials to aid in the recovery of plutonium. For the most recent recovery campaigns, the host matrix containing the most material was plastic. Surface leaching techniques have not been successful, and sonication-aided leaching may not be amenable. Pyrolysis (high-temperature decomposition in the absence of oxygen) would be developed, demonstrated, and deployed to create an ash from the plastic that then would be processed by more aggressive dissolution techniques. Although pyrolysis has been developed and deployed for cellulose, it has not been modified for treating the wide variety of plastics generated in glovebox operations.

Casting Improvements (SR). This project would develop and implement improved casting technologies to reduce the amount of feed material required. Improved efficiencies in the casting and manufacturing areas also could be important in reducing losses from those processing areas. In particular, near-net-shape casting would reduce the amount of feed material required for an experiment, and the development and deployment of a reusable casting mold would reduce waste and minimize the amount of residues requiring processing for material recovery. Reducing the amount of feed material required for an experiment will reduce the volume of LLW and TRU waste generated.

CMR Facility Assay and Compaction (T). This project would implement an assay and compaction process for glovebox waste at the CMR Facility. That improvement would reduce the generation of TRU/MTRU solid waste by up to 3 m^3/yr.

State-of-the-Art NDA Instrumentation (SR). This project would purchase and install state-of-the-art NDA instrumentation for the characterization of radioactive waste at TA-55. NDA is used to determine the radiological characteristics of TRU waste as part of the characterization process. Because of background radiation levels, the current instrumentation is not sensitive enough to distinguish clearly between LLW and TRU waste concentrations. These high levels of background radiation require that the LLW be categorized as TRU waste until further characterization is performed at another facility. Those low-level radioactive wastes that previously were categorized as TRU waste are separated and removed from the TRU waste stream at this point in the characterization process. Proper characterization and separation of TRU waste materials from LLW will reduce the amount of TRU waste generated and resolve issues related to differences in data generated during the characterization of the waste and that data generated during the safeguards and security assay at TA-55.

Launderable Materials for Contamination Control Pilot (SR). This project would pilot the use of launderable plastic sheet goods used for contamination control. If successful, the launderable materials would replace their disposable counterparts. The use of launderable materials will reduce the volume of radioactive waste produced.

Nonhalogenated Plastic Materials (SR). This project would pilot the replacement of polyvinyl chloride (PVC)-based plastic goods with nonhalogenated plastics and polyvinyl alcohol (PVA) counterparts to reduce the corrosive off-gas produced during thermal decomposition. The use of PVA will allow the exploration of dissolution of the PVA personnel protective equipment (PPE) using commercially available technology at a throughput rate large enough to decompose much of the low-level combustible waste stream in addition to the TRU/MTRU waste volumes. If successful, replacement of the PVC materials will reduce the generation of combustible LLW, TRU, and MTRU waste.

NDA (SR). To maintain good process control, a significant and integrated level of analytical chemistry is required. Because of the lack of radiation signature from some material, the Laboratory must rely on destructive chemical analysis using estimates of the isotopic composition for routine process control and material accountability. Advances in analytical chemistry and NDA have made elemental destructive assay available (no reliance on providing isotopic input), as well as possible nondestructive solution assay advances that would be applicable to this unique material's isotopic makeup. This project will implement advances in NDA to improve process control and material accountability and includes equipment procurement and fabrication and software modification. Better process control will reduce the amount of material that must be processed as radioactive waste.

Sphere-Size Reduction (T). This project applies to the Laboratory-generated testing spheres that must be managed as TRU waste. This project will develop/demonstrate methods of cleaning and decontaminating the containers. Methods developed/ demonstrated could include sphere cutting, cleaning with a magnetic robotic crawler, and chemical or plasma decontamination.

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3.0. LOW-LEVEL WASTE

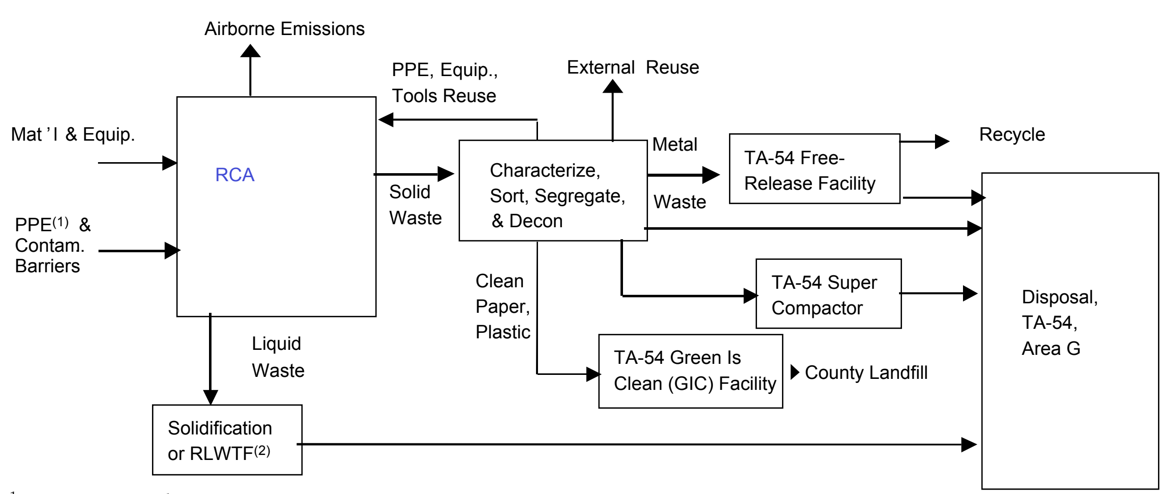
3.1. Introduction

Low-level waste (LLW) is defined as waste that is radioactive and is not classified as high-level waste (HLW), transuranic (TRU) waste, spent nuclear fuel, or by-product materials (e.g., uranium or thorium mill tailings). Test specimens of fissionable material irradiated only for research and development and not for the production of power or plutonium may be classified as LLW, provided that the activity of TRU waste elements is <100 nCi/g of waste.

Disposal of LLW is governed at Los Alamos National Laboratory (the Laboratory) by its waste acceptance criteria (WAC), which also drives LLW reporting requirements. These criteria place limits on the physical, chemical, and radiological characteristics of acceptable LLW and are developed from Department of Energy (DOE) Orders, federal and state laws and requirements, and site characteristics. Laboratory Implementation Requirement (LIR) 404-00-05.1, *Managing Radioactive Waste*, provides guidance specific to LLW; and LIR 404-0002.2, *General Waste Management Requirements*, contains waste minimization requirements.

Figure 3-1 depicts the process map for LLW generation at the Laboratory.

Routine LLW generation by division is depicted in the pie chart in Fig. 3-2. Nuclear Materials Technology (NMT) Division and Facility and Waste Operations (FWO) Division generate the largest quantities of routine LLW. The routine solid LLW generation values for each division are listed in Table 3-1.



[1]PPE = personnel protective equipment.
[2]RLWTF = Radioactive Liquid Waste Treatment Facility.

Fig. 3-1. Top-level LLW process map and waste stream chart.

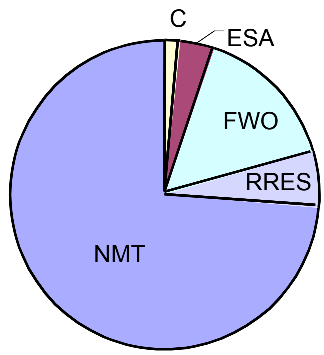


Fig. 3-2. Routine waste generation by division.

TABLE 3-1
ROUTINE LLW GENERATION BY DIVISION

Division	Total (m^3)
C (Chemistry)	5.8
RRES (Risk Reduction and Environmental Stewardship Division)	22.4
ESA (Engineering Sciences and Applications)	15.3
FWO	54.5
NMT	274.0
Total	372.0

3.2. Low-Level-Waste Performance

The DOE has implemented goals for waste minimization. Its environmental leadership program will go beyond compliance requirements and will be based on continuous and cost-effective improvements. To achieve these goals, the Laboratory will use an Environmental Management System (EMS) to evaluate environmental hazards and define the highest-priority hazards and the most cost-effective solutions to reduce the environmental impacts from these hazards.

The LLW reduction goal for fiscal year (FY)05 is to reduce waste from routine operations by 80% by 2005, which will be calculated using calendar year (CY)93 as the baseline, as required by the DOE. Figure 3-3 shows the Laboratory's success in achieving this goal and clearly illustrates that the Laboratory has exceeded the 2005 goal. In Fig. 3-3, values for the volume of routine waste subsequent to FY01 include compaction. In previous years, the values did not include compaction.

3.3. Waste Stream Analysis

Materials, hardware, equipment, personnel protective equipment (PPE), and contamination barriers (paper and plastic) are used in radiological control areas (RCAs). After these items are no longer needed, they leave the RCA after being sorted, segregated, and, if possible, decontaminated. Some PPE, equipment, and tools are reused at the Laboratory, whereas other equipment is sent off site for reuse. Compactable waste is sent to the Technical Area (TA)-54, Area-G compactor for volume reduction before disposal. Much of the waste leaving RCAs is not radiologically contaminated and can be surveyed to determine if the waste meets the radiological release criteria. If so, it is recycled or disposed of as sanitary waste. Low-density waste is sent to the GIC Facility at TA-54, Area G for verification that it meets the radiological release criteria. It then is sent to the County Landfill for disposal. The LLW streams are broken down by percent in Fig. 3-4.

Solid LLW generated by the Laboratory's operating divisions is characterized and packaged for disposal at the onsite LLW disposal facility at TA-54, Area G. LLW minimization strategies are intended to reduce the environmental impact associated with LLW operations and waste disposal by reducing the amount of LLW generated and/or by minimizing the volume of LLW that will require storage or disposal on site. LLW minimization is driven by the finite capacity of the onsite disposal facility and by the requirements of DOE Order 435.1 and other federal regulations and DOE Orders.

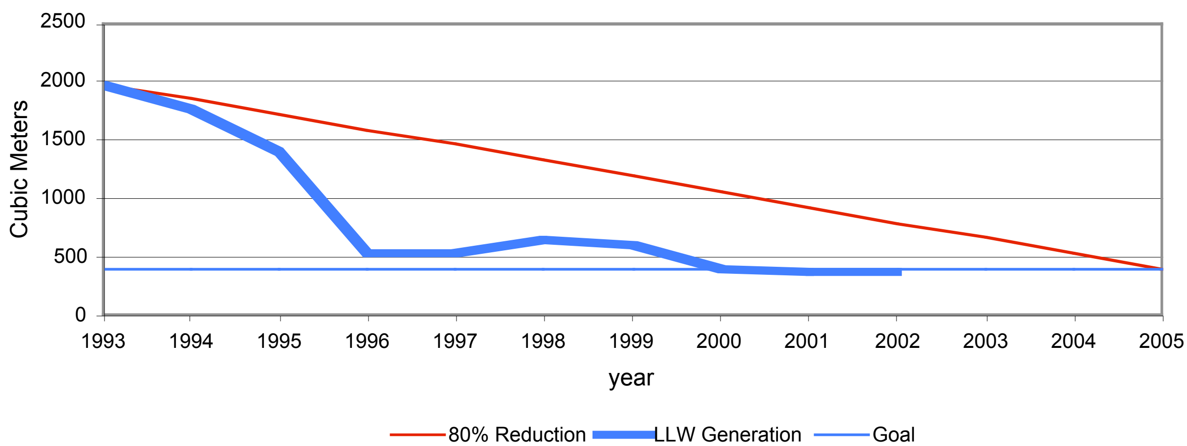


Fig. 3-3. Chart demonstrating that the Laboratory has exceeded the 2005 goal.

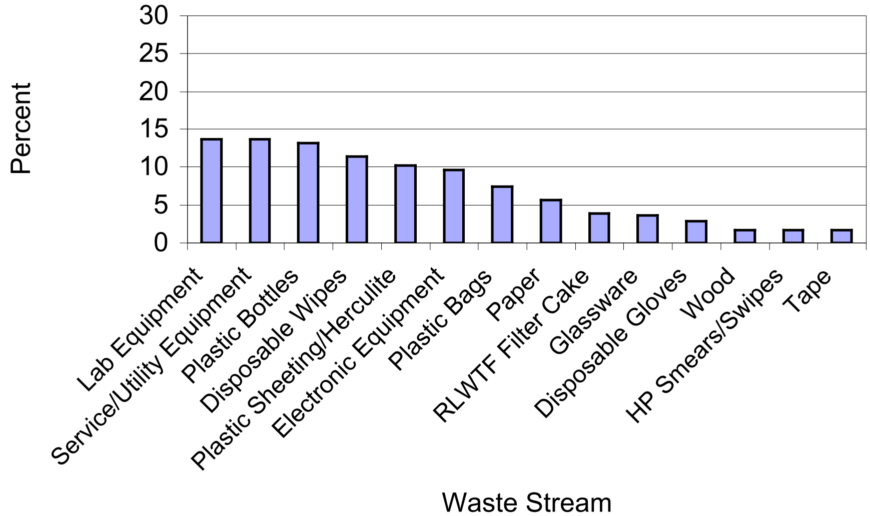


Fig. 3-4. Routine LLW streams.

Liquid LLW typically is generated at the same facilities that generate solid LLW. It is transferred through a system of pipes and by tanker trucks to the RLWTF at TA-50, Building 1. The radioactive components are removed and disposed of as solid LLW. The remaining liquid is discharged to a permitted outfall.

Unlike other waste, waste produced from decommissioning and environmental restoration (ER) projects will be disposed of either at the Envirocare site in Utah, *in situ*, or at Area G and is not addressed in this LLW section.

Solid LLW comprises various waste streams that are categorized as combustible LLW, noncombustible LLW, and scrap-metal LLW. LLW is generated when materials, equipment, air, and water brought into RCAs to assist in performing work are contaminated radiologically and then removed from the facility in the form of air emissions, solid LLW, or aqueous LLW.

The LLW streams at the Laboratory arise from processes at various Laboratory sites and are interrelated in some cases. For example, significant quantities of Laboratory equipment (e.g., computers) contain circuit boards that must be disposed of as MLLW. The goal of the TRU program is to lower the radiation levels of gloveboxes from TRU to LLW levels through decontamination; the goal of the LLW program is to use all means possible to release the maximum materials for recycle, reuse, or sanitary waste disposal. LLW streams are categorized in the following subsections as combustible, noncombustible, or scrap metal. The categorized waste streams and their definitions follow.

3.3.1. Combustible Waste Streams

Materials from combustible waste streams used to accomplish programmatic work in RCAs are processed as LLW when they are removed. Combustible materials make up

~55% of the routine LLW produced at the Laboratory annually. Combustible LLW streams and their definitions follow in descending order by volume.

Plastic Bottles. Plastic bottles are used to contain aqueous samples and move aqueous material from one RCA to another.

Disposable Wipes. Disposable wipes consist of any absorbent product (paper towels, wipes, cheese cloth, etc.) used as a cleaning aid or to absorb aqueous materials. Most of these wipes either are used as laboratory aids or are contaminated during cleanup activities.

Plastic Sheeting/Herculite. Plastic sheeting is used for contamination barriers. Typically, it is placed on the floor areas or used to build containment structures around equipment to prevent the spread of radioactive contamination and to ease cleanup activities.

Plastic Bags. Plastic bags are used to package waste for disposal and to transport materials from one RCA to another.

Paper. Office paper is used for recording data, working procedures, etc. Other forms of paper, such as brown wrapping paper, are used as temporary contamination barriers to prevent the spread of contamination and to ease cleanup activities.

RLWTF Filter Cake. The RLWTF uses a ferric chloride flocculation agent to precipitate contaminates as part of the treatment process for the radioactive liquid effluent. This waste stream consists of the filter cake that results from this process.

Disposable Gloves. Disposable gloves are an essential PPE requirement when working in RCAs. Disposable gloves offer a high level of dexterity. If more protection is required, a heavier, more launderable pair of gloves can be worn over the disposable gloves.

Wood. Wood is used as a construction material to erect temporary containment structures. It is introduced into RCAs in the form of wooden pallets, scaffolding planks, and ladders. Wood also is used to support heavy objects being packaged for disposal to ensure that the objects do not shift in their packing container during transport.

Tape. Tape serves many purposes within RCAs, such as to seal PPE. It is also used to fix plastic and paper contamination barriers in place.

HP Smears/Swipes. This material consists of filter paper and large "masslin" swipes used to monitor removable contamination levels within RCAs.

3.3.2. Noncombustible Waste Streams

Noncombustible materials make up ~45% of the routine LLW produced at the Laboratory annually. Noncombustible LLW streams are defined in the following list.

Laboratory Equipment. This waste stream consists of a variety of laboratory equipment that is either outdated, no longer functional, or unusable. This waste stream consists of hot plates, furnaces, centrifuges, computers, and a variety of miscellaneous analytical instrumentation.

Building Service/Utility Equipment and Tools. This waste stream consists of a variety of work tools, as well as equipment used to provide basic facility services, such as pumps, ventilation units, and compressors. This equipment generally is removed during facility maintenance or upgrade activities.

Electronic Equipment. This waste stream consists of a variety of equipment, including computer, miscellaneous laboratory and building services, and utilities electronic equipment. This equipment is expensive to dispose of because it is difficult to characterize and because many of the components are classified as hazardous waste; therefore, this equipment must be either disposed of as MLLW or recycled.

Glassware. This waste stream consists of laboratory glassware that no longer can be used because it cannot be cleaned well enough to prevent the cross contamination of samples.

3.4. Improvement Projects

The following projects were identified as potential corrective measures for the LLW type. These projects are divided into three categories: (1) projects completed in the last year, (2) projects currently funded and ongoing, and (3) unfunded proposed projects. Projects are characterized further by type: source reduction (SR), sort and segregate (SS), reuse/recycle (RR), treatment (T), or disposal (D).

3.4.1. Completed Projects

These projects have been completed and/or implemented in the last year. Many projects completed in previous years, especially sort and segregate and recycle/reuse projects, continue to avoid LLW.

Labware-Cleaning: Nitric Acid (SR). It was not known if the volume of nitric acid used for labware cleaning each year could be reduced and still maintain acceptable actinide and metal blanks. This project evaluated the effect of reducing the use of nitric acid for cleaning labware. Two ideas were evaluated in parallel: (1) how many times can the nitric acid be reused before the level of the actinide blanks associated with the labware starts to rise, and (2) can the 1:1 nitric cleaning of labware be eliminated and still retain a low level of blanks. Based on the results, we now know that we can reuse nitric acid safely in our cleaning process. We estimate that our future nitric acid use can be reduced by 75 to 200 L annually. In addition, we have shown that the 1:1 nitric step could be eliminated for much of our labware for an additional reduction.

3.4.2. Ongoing Projects

These projects have been funded and currently are being executed. All of the ongoing LLW projects are funded by the Prevention Program (PP) Office Base and Generator Set-Aside Fee (GSAF) Program.

GIC (SS). It is estimated that 50% of the LLW stream is not contaminated. Through the use of acceptable knowledge and segregation techniques, a large portion of this waste stream can be eliminated. A verification facility with sophisticated counting instrumentation was established at TA-54 to perform verification surveys on waste that was segregated based on acceptable knowledge before it was disposed of as sanitary waste. In addition, sitewide implementation procedures were developed. The PP still supports this project as part of its base program activities. Support consists of working with generators to define acceptable knowledge and segregation techniques better. In FY02, a GSAF project was initiated to enhance the throughput of the GIC waste verification facility from 50 to 100 m^3 annually.

Launderable Product Substitution (SR). This project increases the use of launderable PPE at the Laboratory to eliminate disposable PPE. The PP Office still is supporting this project as part of its base program to encourage the use of launderable wipes, mops, bags, and contamination barriers to eliminate further the use of disposable products. In FY02, a GSAF project to implement the use of launderables to minimize job control waste at TA-55 was funded.

Job Control Waste Minimization (SR). Large quantities of paper and plastic waste are generated during operational and maintenance activities at the Laboratory and must be disposed of as LLW. Typically, the floor of the room surrounding the work activity is covered with plastic sheeting. In many cases a temporary wall is built with wooden 2-in. x 4-in. studs and covered with plastic sheeting for additional contamination control. After the work activity is completed, all of this material is disposed of as LLW. This project consists of two elements: a job control waste minimization project within NMT Division and a broader glovebag/enclosure element that includes the use of glovebags at TA-54 as well as at NMT. The NMT project is a 2002 GSAF award project. This project minimizes job control waste by substituting launderable materials, glovebags, and other job control waste minimization techniques for single-use waste-control items.

The broader project will deploy and pilot containment systems that have been in wide use elsewhere for years. These containment systems consist of everything from small glovebags, built from plastic sheeting, that are designed to fit around a specific work activity to large plastic tent-like structures for larger work activities. The tent-like structure can be erected easily and then disassembled and stored for future use if it is not contaminated. Otherwise, the plastic tent can be disposed of and the tent structure reused. The small glovebag systems generally are disposed of after a single use. In either case, the amount of LLW generated is significantly less than the waste generated by protecting the entire area around a work activity.

Compactor Box Deployment to RCAs (T). LLW is placed in 2-ft^3 cardboard boxes or large (96-ft^3 or 48-ft^3) steel waste containers for disposal. Large amounts of job control waste and other compactable waste are placed in the large steel containers (B-25 boxes) because they are too large to fit in the small cardboard containers. These materials cannot be compacted. Use of the steel compactor boxes is not possible because Business Operations (BUS) Division will not certify these boxes for transportation on a public highway. This project will fund the design for new compactor boxes that meet the transportation requirements so that these large materials can be compacted and the volume of the LLW stream reduced. In addition to meeting the transportation requirements, the new boxes will be designed to meet the security (lockable) requirements for TA-55.

3.4.3. Project Development and Unfunded Projects

Currently, no unfunded or project development activities have been proposed for LLW.

4.0. MIXED LOW-LEVEL WASTE

4.1. Introduction

For waste to be considered mixed low-level waste (MLLW), it must contain Resource Conservation and Recovery Act (RCRA) materials and meet the definition of radioactive LLW. LLW is defined as waste that is radioactive and is not classified as high-level waste (HLW), transuranic (TRU) waste, spent nuclear fuel, or by-product materials (e.g., uranium or thorium mill tailings). Test specimens of fissionable material irradiated only for research and development (R&D) and not for the production of power or plutonium may be classified as LLW, provided that the activity of TRU waste elements is <100 nCi/g of waste. Because MLLW contains radioactive components, it is regulated by Department of Energy (DOE) Order 435.1. Because it contains RCRA waste components, MLLW also is regulated by the State of New Mexico through Los Alamos National Laboratory's (the Laboratory's) operating permit, the Federal Facility Compliance Order/Site Treatment Plan (FFCO/STP) provided by the New Mexico Environment Department (NMED), and the Environmental Protection Agency (EPA). Materials in use that will be RCRA waste upon disposal are defined as hazardous materials.

Most of the Laboratory's routine MLLW results from stockpile stewardship and management and from R&D programs. Most of the nonroutine waste is generated by off-normal events such as spills in legacy-contaminated areas. Environmental restoration (ER) and waste management legacy operations, which also produce MLLW, are not included in this roadmap. Typical MLLW items include contaminated lead-shielding bricks, R&D chemicals, spent solution from analytic chemistry operations, mercury-cleanup-kit waste from broken fluorescent bulbs and mercury thermometers, circuit boards from electronic equipment removed from a TRU waste radiation area, discarded lead-lined gloveboxes, and some contaminated water removed from sumps.

Figure 4-1 shows the process map for MLLW generation at the Laboratory.

Routine waste generation by division is displayed in Fig. 4-2.

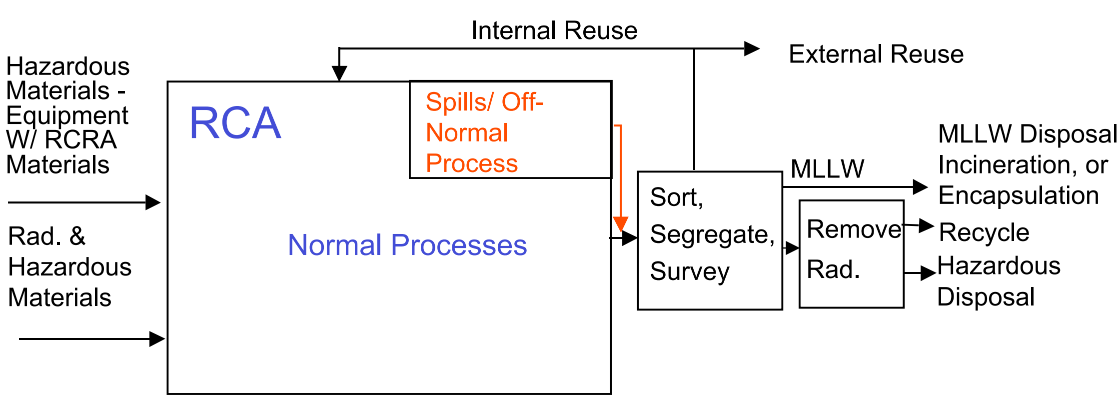


Fig. 4-1. Top-level MLLW process map.

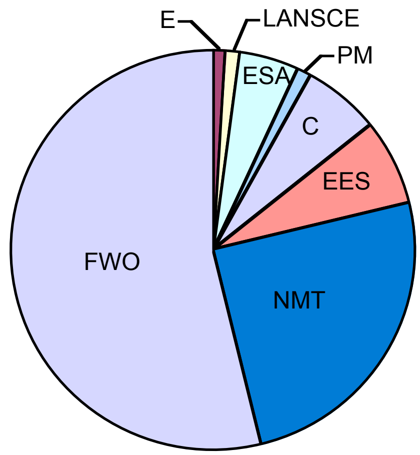


Fig. 4-2. Total MLLW generation by division.

Facility and Waste Operations (FWO), Nuclear Materials Technology (NMT), Engineering Sciences and Applications (ESA), and Earth and Environmental Science (EES) Divisions were the largest producers of routine MLLW in fiscal year (FY)02. The biggest contributor to the routine waste volume was electronics from their sort-and-segregation activities. The largest contributor to FWO waste volumes was hard, dry, metals containing paint.

Routine MLLW generation is shown by year in Fig. 4-3.

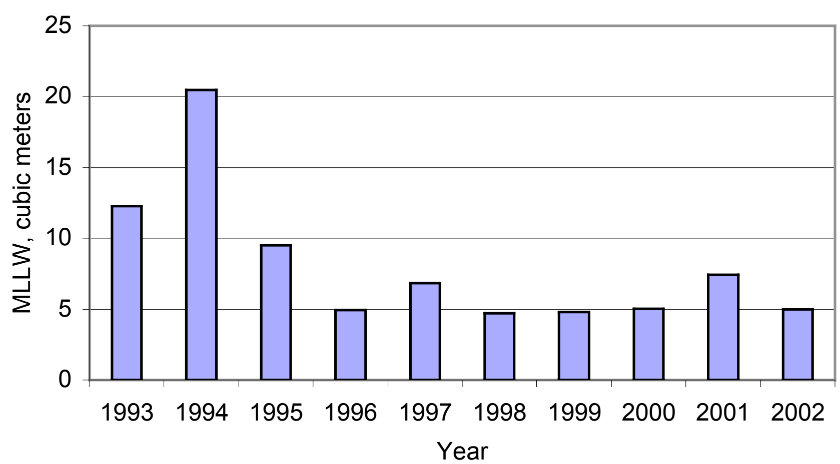


Fig. 4-3. Routine waste generation.

4.2. MLLW Minimization Performance

The DOE has implemented goals for waste minimization. The DOE-proposed MLLW goal is to reduce MLLW from routine operations by 80% by 2005 using calendar-year (CY)93 as the baseline. Because the MLLW generation in the baseline year was a low 12.3 m^3, the proposed DOE FY05 goal would be a very low 2.5 m^3. MLLW generation at the Laboratory is currently only 5.5 m^3/yr. The Laboratory has proposed MLLW reduction projects that could reduce MLLW generation over the next 4 years. These projects include elimination of RCRA hazardous paint strippers, solidification of MLLW hydraulic oils, and improvements in chemical analysis processes. The Laboratory will continue to make every effort to reduce the MLLW generation to the lowest possible level consistent with funding and operational constraints.

Figure 4-4 shows the Laboratory's progress toward achieving this goal. For the past 3 years, the Laboratory has averaged ~5.75 m^3 of MLLW. The spike in waste generation of 7.45 m^3 that occurred in FY01 was caused by FY99 and FY00 waste that was placed in the Site Treatment Plan (STP) but not yet received at the disposal site at Technical Area (TA)-54, Area G. All of this waste was added to the FY01 generation rate to avoid further complication of the waste accounting system. The actual FY02 generation was 5.5 m^3.

4.3. Waste Stream Analysis

Routine MLLW is generated in radiological control areas (RCAs). Hazardous materials and equipment containing RCRA materials, as well as MLLW materials, are introduced into the RCA as needed to accomplish specific activities. In the course of operations, hazardous materials become contaminated with LLW or become activated, becoming MLLW when the item is designated as waste.

Typically, MLLW is transferred to a satellite storage area after it is generated. Whenever possible, MLLW materials are surveyed to confirm the radiological contamination levels; if decontamination will eliminate either the radiological or the hazardous component, materials are decontaminated and removed from the MLLW category.

Waste classified as MLLW is managed in accordance with appropriate waste management and Department of Transportation (DOT) requirements and shipped to TA-54.

From TA-54, MLLW is sent to commercial and DOE treatment and disposal facilities. The waste is treated/disposed of by various processes (e.g., segregation of hazardous components and macroencapsulation or incineration).

In some cases, the Laboratory procures spent MLLW materials from other DOE/commercial sites. For example, in FY01 the Los Alamos Neutron Science Center Experiment (LANSCE) designed several new beam stops and shutters

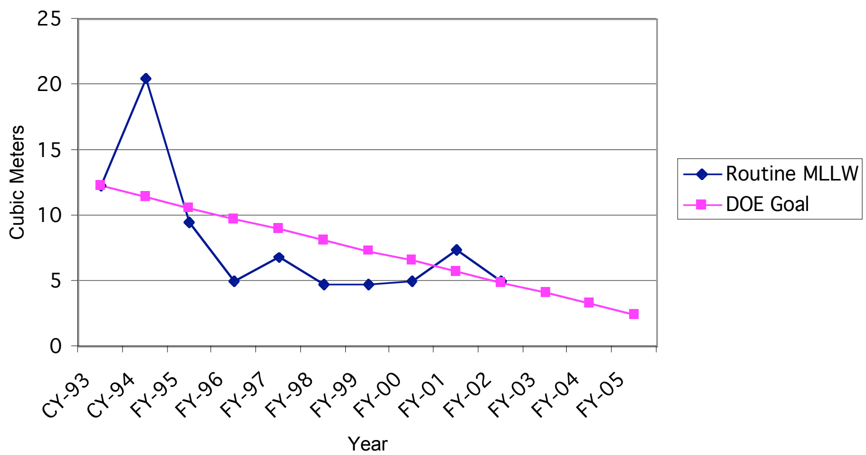


Fig. 4-4. Routine MLLW generation vs the DOE goal.

from lead. Rather than fabricating these from uncontaminated lead, LANSCE received these parts at no expense from GTS Duratek (formerly SEG), a company that processes contaminated lead from naval nuclear reactor shielding. Duratek fabricates parts at no cost to the Laboratory because their fabrication costs are much less than those of MLLW lead disposal.

The largest FY02 waste streams are generated from bioassayed waste. These waste streams constitute over 50% of the MLLW waste type and are the primary targets for reduction or elimination. The individual waste streams are as follows.

Bioassay Solution (2.08 m^3). This waste is generated by the Laboratory's ongoing bioassay program. The waste consists of assay reagents, which are typically rich in nitrates and trace quantities of radionuclides. Previously, this waste stream was disposed of at the Radioactive Liquid Waste Treatment Facility (RLWTF). To meet new nitrate regulatory limits, the nitrate waste is being collected in carboys for offsite disposal.

Paint and Painting Debris (0.61 m^3). This waste consists of leftover, unused paint and items such as rags and stirrers that are contaminated with paint.

Wet Sand with Rust (0.17 m^3). This material was generated by NMT Division and consisted of a wet sand-like material mixed with rust from the drum containing the material. It was presumed to be MLLW rather than LLW.

Tritium Analysis Waste Water (0.17 m^3). This waste stream consists of the wastewater left over after analytical procedures for tritium contamination are completed.

Soil Samples (0.09 m^3). MLLW samples are taken and analyzed routinely to determine radioactivity and hazardous constituent levels. This waste stream consists of the unused samples left over after the analytical procedures and treatability studies have been completed.

Calcium Metal (0.09 m^3). This MLLW stream consists of unused/unspent, partially oxidized calcium metal removed from an RCA. The metal no longer was needed for the intended purpose and, because of the oxidation, may no longer be usable.

Paint Sludge with Metal (0.08 m^3). This waste stream is composed of radionuclide-containing paint sludges from stripping or cleaning operations.

Miscellaneous (0.08 m^3). This category consists of contaminated water, decontamination fluids, unused commercial products, and other miscellaneous materials.

Efforts to substitute alternatives and to improve sorting and segregation of these waste streams should reduce these volumes dramatically in the coming years. Nitric acid waste, paint/paint debris waste, and MLLW electronics are ongoing waste streams for which substantial improvement is possible. Improvement projects have been proposed that will lead to a reduction in MLLW. In the following sections, these projects are discussed.

MLLW cost an average of $36.84/kg to characterize, treat, and dispose of in FY02. Table 4-1 summarizes the Laboratory's typical unit costs for MLLW disposal. Waste is disposed of either by incineration or by macroencapsulation and land disposal. Macroencapsulation involves potting the waste (typically solid parts) in a suitable plastic and creating a barrier around the waste.

The relative size of the various waste streams, expressed in percent, is shown in Fig. 4-5.

A small fraction of the MLLW generated has no disposal path. Typically, this waste is radiation-contaminated mercury or mercury compounds.

4.4. Improvement Projects

The following projects were identified as potential corrective measures for the MLLW type. These projects are divided into three categories: (1) projects completed in the last year, (2) projects currently funded and ongoing, and (3) unfunded proposed projects. Projects are characterized further by type: source reduction (SR), sort and segregate (SS), reuse/recycle (RR), treatment (T), or disposal (D).

4.4.1. Completed Projects

These projects have been completed and/or implemented in the last year. Many projects completed in previous years, especially sort and segregate and recycle/reuse projects, continue to avoid MLLW.

Oil-Free Vacuum Pumps (SR). This project piloted the replacement of oil-filled vacuum pumps used in RCAs. Oil-free replacement pumps were purchased to replace the oil-filled pumps. The use of these pumps eliminated nearly all of the MLLW oil produced at certain Laboratory facilities. Because of this successful pilot, the use of oil-free vacuum pumps in RCAs is being expanded.

TABLE 4-1
APPROXIMATE COSTS FOR MLLW STREAMS[4-1]

Waste Type	Treatment Method	Treatment and Disposal Cost	Transportation Cost
Activated or inseparable lead	Macroencapsulation	$15,000/m^3$	$5000 per shipment
Surface-contaminated lead (for offsite recycling)	Standard decontamination methods (bead blasting, acid dip, etc.), followed by recycling	$8000/m^3$	$5000 per shipment
RCRA waste-regulated solvents with radioactive components	Fuel recycling in Diversified Scientific Services, Inc. (DSSI)-permitted boiler	$19,815 to $52,840/m^3$. Actual costs depend on levels of radionuclides, metal content, percent water, etc.	$5000 per shipment
Activated RCRA waste components	Macroencapsulation	$15,000/m^3$	$5000 per shipment
Fluorescent tubes with mercury	Amalgamation followed by landfill disposal	$105,900/m^3$	$5000 per shipment
Printed circuit boards	Macroencapsulation	$15,000/m^3$	$5000 per shipment

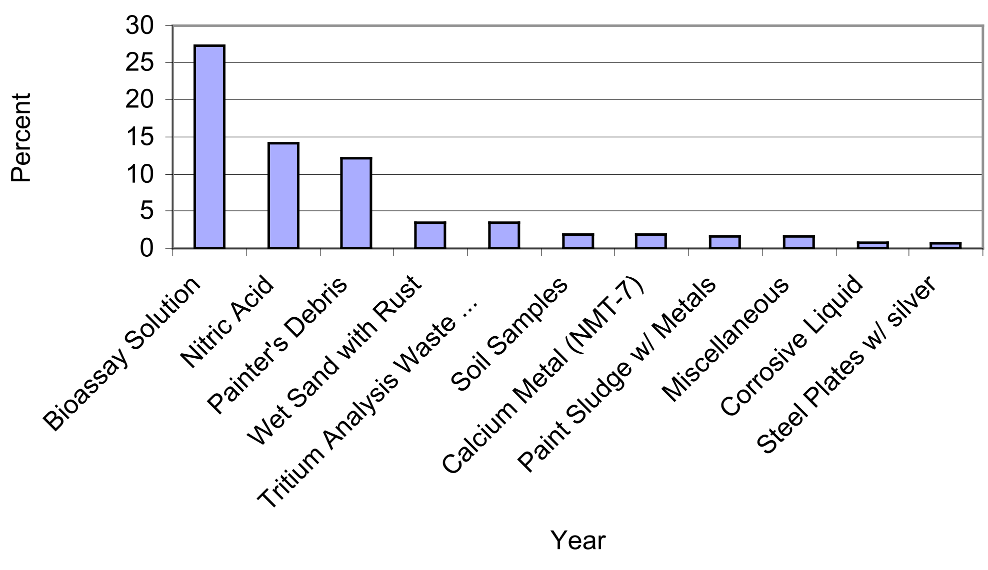


Fig. 4-5. Waste stream constituents.

Upgrade of Mercury Shutters (SR). The mercury beam shutters at the LANSCE facility are the major source of mercury-contaminated waste at the Laboratory. This project will redesign these shutters to eliminate this source of contamination.

LANSCE MLLW Reduction Project (SS). This project will implement the sorting and segregation techniques learned during the mercury-contaminated radiation waste reduction project performed during FY01.

Lead Removal from Gloveboxes (RR). Gloveboxes decontaminated to LLW levels are classified as MLLW because of the lead shielding present. This project funded the development of techniques to remove the lead and recycle the lead shielding. The lead from several gloveboxes was recycled as part of this project. This project will be incorporated into the Decontamination and Volume Reduction System (DVRS) in the future.

4.4.2. Ongoing Projects

These projects have been funded and currently are being executed. All of the ongoing MLLW projects are funded by the Prevention Program (PP) Base and Generator Set-Aside Fee (GSAF) Program.

Sorting, Segregation, Recycle, and Reuse of Electronic Equipment (SS). Miscellaneous electronic equipment leaving RCAs is disassembled, and the individual components are surveyed. Those components that are nonradioactive are recycled. It is estimated that this project avoids up to 10 m^3 annually of MLLW generation.

Sorting, Segregation, Recycle, and Reuse of Miscellaneous Equipment from RCAs (SS). Equipment or materials (copper pipe with lead solder joints) are disassembled and surveyed. Materials that can be determined as nonradioactive are recycled.

TA-48, RC-45 Nitrate Waste Elimination (T). The bioassay laboratory at TA-48, RC-45 generates 1 m^3 of MLLW annually. This waste is liquid nitrate waste that can no longer be disposed of at the RLWTF. Currently, this waste is being accumulated in carboys and sent off site for disposal as MLLW. Because of the low radiological levels present in this waste stream, the waste can be discharged to the Sanitary Wastewater Systems Consolidation (SWSC) facility. To discharge the waste to this facility, a sump, collection, and neutralization system must be installed to route this waste to the SWSC facility. This proposal seeks the funds to install this system. After installation, this facility no longer will generate this waste stream.

Oil Solidification (T). Contamination of oils with radioisotopes is a common problem in RCAs. These oils become MLLW and must be disposed of as such. Recent tests, using the NoChar solidification media developed at Mound Laboratory, indicate that if the oil is solidified with this product, the oil would pass toxic-characteristic leaching-procedure (TCLP) testing and could be buried as LLW, saving substantial waste disposal costs. This project is providing the data necessary to adopt and use this technology for routine management of contaminated oil wastes. When implemented, it is estimated that this process will eliminate up to 0.75 m^3 of MLLW generation annually.

4.4.3. Project Development and Unfunded Projects

These projects either have been proposed or are under development to help reduce MLLW. Proposed projects that currently are unfunded and projects under development are designated as such.

Improved Plutonium and Americium Analytical Methods for Environmental Matrices (SR) (Unfunded). Current methods for radioisotopic analyses of plutonium and americium in soil and water samples by alpha spectrometry performed by the Isotope and Nuclear Chemistry Group in the Chemistry Division (C-INC) largely were developed 15 or more years ago. Several modifications to the digestion, separation, electroplating, and counting steps of these methods, which should significantly improve the overall analyses, have been proposed. For soils, the aliquot size will be reduced from 10 to 5 g, and the count length will be increased from 22 to 50 hours to maintain the current sensitivity level of 0.002 pCi/g soil. For water samples, the current sample size will be maintained but the count length will be increased to 50 hours, resulting in improved sensitivity. Operational benefits include a reduction in both liquid waste discharges and airborne emissions, improvements in operational efficiency, reductions in the cost and time required to complete the analyses, reduced exposure to hazardous chemicals to workers, and simplification of operations. These benefits will extend to future years.

Reduction of Total Nitrate-Containing Waste in Sample Coprecipitation Methods (SR) (Unfunded). This project proposes a modification of current methods to reduce the production of total nitrate waste in the urine bioassay for uranium and americium. Modifications in the precipitation and ion-exchange steps may result in the elimination of ~70% of the total nitrates produced by the current process. New ion-exchange technology has yielded a class of resins that requires much smaller volumes and a lower concentration of acids. Precision and accuracy of the data produced by these new technologies are unchanged. Changes in coprecipitation and the use of these new resins could reduce the total nitrates produced in this preliminary step. Added benefits include a reduction in both liquid waste discharges and airborne emissions, improvements in operational efficiency, reductions in cost and time required to complete the analyses, reduced exposure of hazardous chemicals to workers, and simplification of operations.

Mercury Amalgamation (T) (Development). The Laboratory does not use the treatment standard for disposal of elemental mercury (i.e., amalgamation). The Laboratory adds elemental mercury to the debris collected during spill cleanup activities, although it is much more cost effective to amalgamate the elemental mercury so that it can be handled as a non-RCRA waste. Mercury spills generated in radiological areas generate MLLW, which frequently has no path to disposal; disposal also is very expensive when it is an available option. This project would develop suitable methods to collect and amalgamate elemental mercury during spill cleanup activities and avoid the generation of this MLLW stream.

If these projects are implemented, the Laboratory expects to see a significant reduction in MLLW next year. These projects address the routine components of the MLLW stream.

5.0. HAZARDOUS WASTE

5.1. Introduction

Hazardous waste is divided into three waste types: Resource Conservation and Recovery Act (RCRA) waste, Toxic Substances Control Act (TSCA) waste, and State special solid waste. For the purposes of reporting the waste minimization, Los Alamos National Laboratory (the Laboratory) distinguishes between routine and nonroutine waste generation. Routine generation results from production, analytical, and/or other research and development (R&D) laboratory operations; treatment, storage, and disposal operations; and "work for others" or any other periodic and recurring work that is considered to be ongoing. Nonroutine waste is cleanup stabilization waste and relates mostly to the legacy from previous site operations.

The RCRA and 40 Code of Federal Regulations (CFR) 261.3, as adopted by the New Mexico Environment Department (NMED), define hazardous waste as any solid waste that

- is generally hazardous if not specifically excluded from the regulations as a hazardous waste;
- is listed in the regulations as a hazardous waste;
- exhibits any of the defined characteristics of hazardous waste (i.e., ignitability, corrosivity, reactivity, or toxicity); or
- is a mixture of solid and hazardous waste.

Hazardous waste also includes substances regulated under the TSCA, such as polychlorinated biphenyls (PCBs) and asbestos.

Finally, a material is hazardous if it is regulated as a special waste by the State of New Mexico as required by the New Mexico Solid Waste Act of 1990 (State of New Mexico) and defined by the most recent New Mexico Solid Waste Management Regulations, 20NMAC 9.1 (NMED), or current revisions. This determination includes the following types of solid wastes that have unique handling, transportation, or disposal requirements to ensure protection of the environment and the public health, welfare, and safety:

- treated formerly characteristic hazardous (TFCH) wastes;
- packing house and killing plant offal;
- asbestos waste;
- ash;
- infectious waste;
- sludge (except compost, which meets the provisions of 40 CFR 503);
- industrial solid waste;
- spill of a chemical substance or commercial product;
- dry chemicals that, when wetted, become characteristically hazardous; and
- petroleum-contaminated soils.

Hazardous waste commonly generated at the Laboratory includes many types of laboratory research chemicals, solvents, acids, bases, carcinogens, compressed gases, metals, and other solid waste contaminated with hazardous waste. This waste may include equipment, containers, structures, and other items that are intended for disposal and that are contaminated with hazardous waste (e.g., compressed gas cylinders). Also included are asbestos waste from the abatement program, wastes from the removal of PCB components, contaminated soils, and contaminated wastewaters that cannot be sent to the sanitary wastewater system (SWS) or high-explosives (HE) wastewater treatment plants.

Most hazardous wastes are disposed of through Duratek Federal Services, a Laboratory subcontractor. This company sends waste to permitted treatment, storage, or treatment storage disposal facilities (TSDFs); recyclers; energy recovery facilities for fuel blending or burning for British-thermal-unit recovery; or other licensed vendors (as in the case of mercury recovery). The treatment and disposal fees are charged back to the Laboratory at commercial rates specific to the treatment and disposal circumstance. The actual cost varies with the circumstances; however, the average cost for onsite waste handling by solid waste operation (SWO) and offsite disposal is $5.92/kg.

Figure 5-1 shows the process map for hazardous waste generation at the Laboratory. The total quantity of routine hazardous waste generated at the Laboratory during the past 5 fiscal years (FYs) is shown in Fig. 5-2.

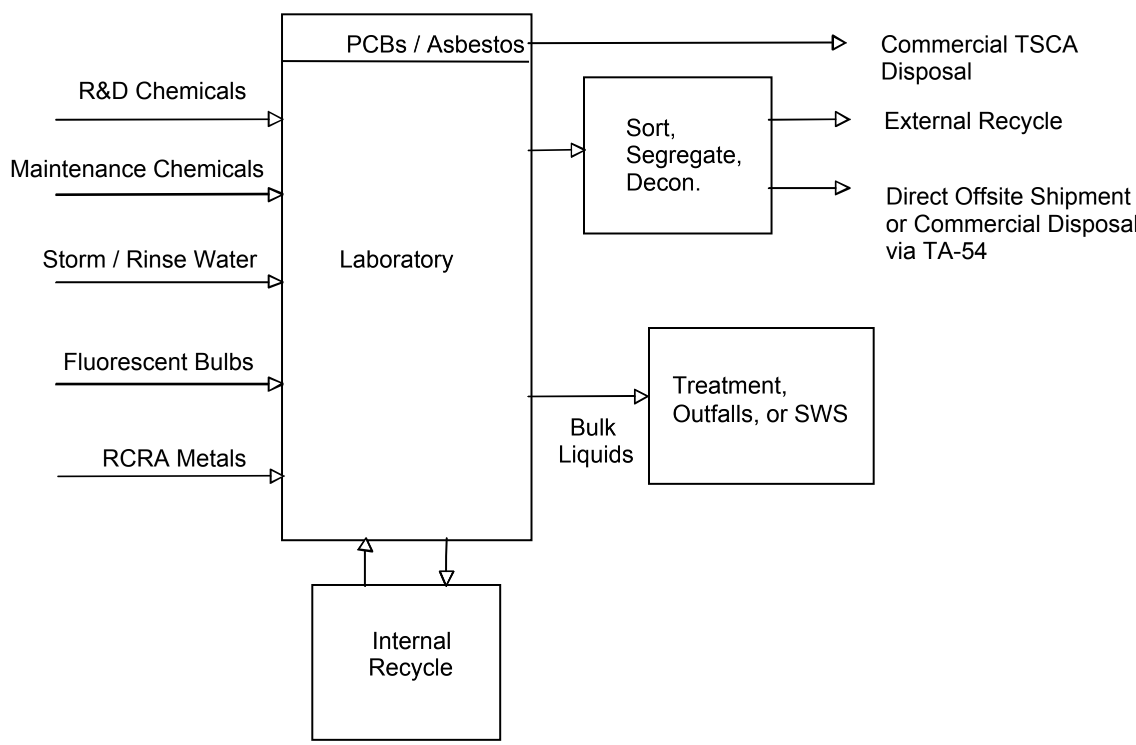


Fig. 5-1. Hazardous waste process map.

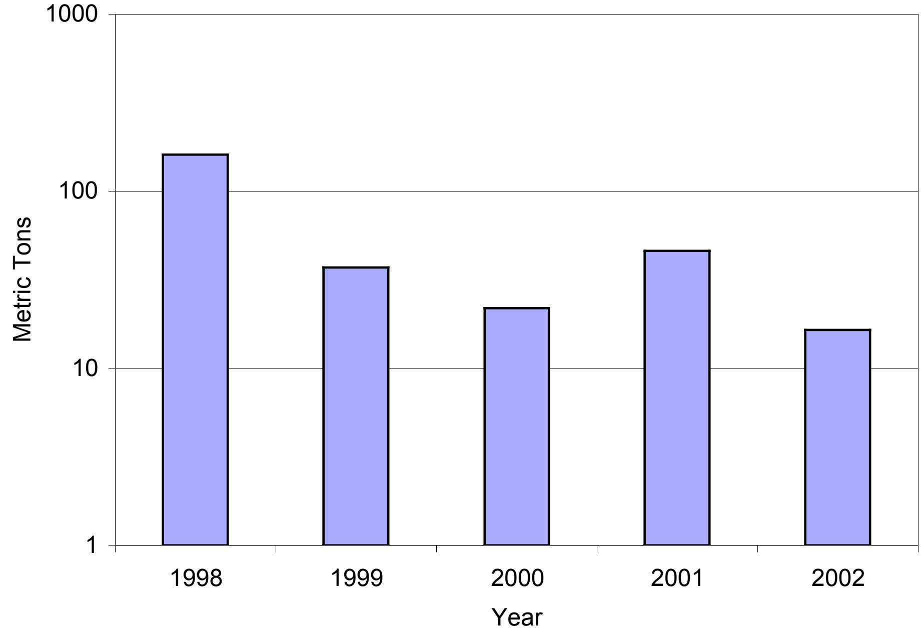


Fig. 5-2. Hazardous waste generation for FY98 through FY02.

Routine hazardous waste decreased sharply from FY98 to FY00 because the Laboratory began excluding recycled hazardous waste from the hazardous waste total. Routine hazardous waste generation unexpectedly increased in FY01. A major factor was the disposal of hazardous wastes that had been recycled in the past. Approximately 10,250 kg of hazardous waste that could have been recycled instead was sent off site for disposal. This action resulted from a conflict between the Laboratory's performance measure for hazardous waste minimization and the waste management performance measure to process waste as quickly and cost effectively as possible. Thus, disposal was chosen over recycling. This issue has been resolved, and wastes that can will be recycled in the future.

As previously discussed, the Laboratory produces three types of hazardous waste: RCRA waste, TSCA waste, and New Mexico special waste, also known as State waste. The quantity of routine RCRA and State waste, along with the quantity of recycled waste, is shown in Fig. 5-3. The waste shown in the figure excludes all nonroutine waste except TSCA. TSCA waste is always considered nonroutine.

The routine hazardous waste generation by division, excluding environmental management–environmental restoration (EM-ER) waste, is shown in the pie chart in Fig. 5-4.

The organizations that produced the most routine hazardous waste in FY01 were Engineering Science and Applications (ESA) and Dynamic Experimentation (DX) divisions. Additional information on hazardous waste, Laboratory procedures for managing hazardous waste, and historical waste generation can be found in Refs. 5-1 through 5-5.

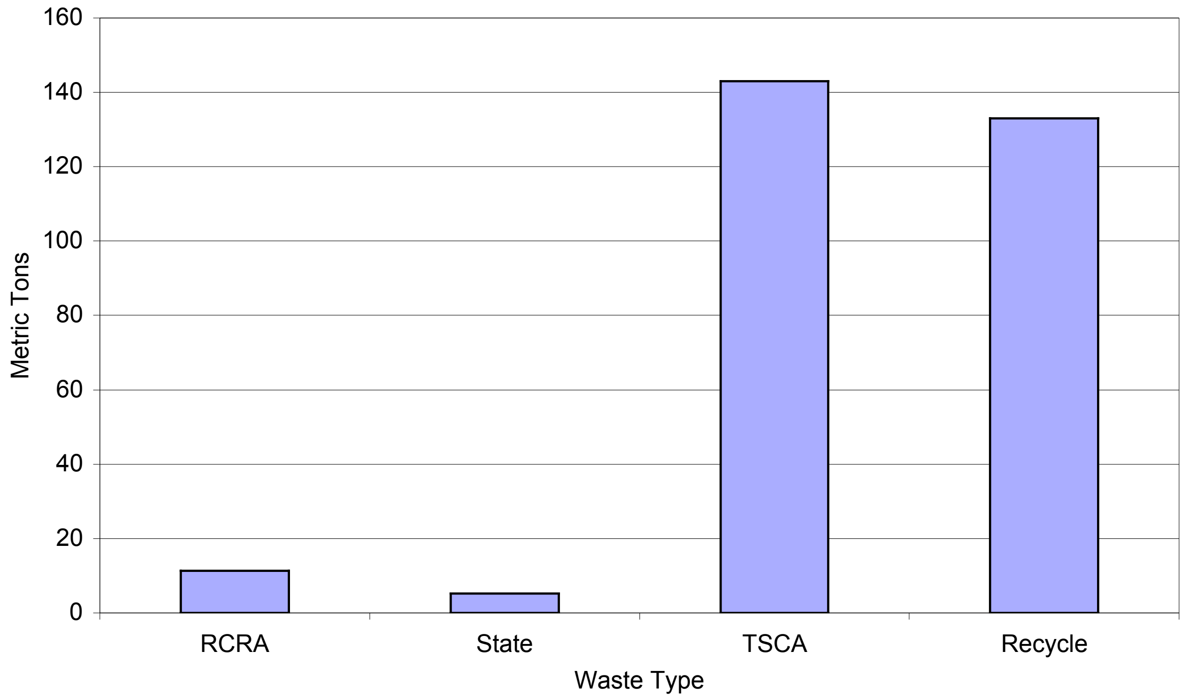


Fig. 5-3. FY01 hazardous waste by type.

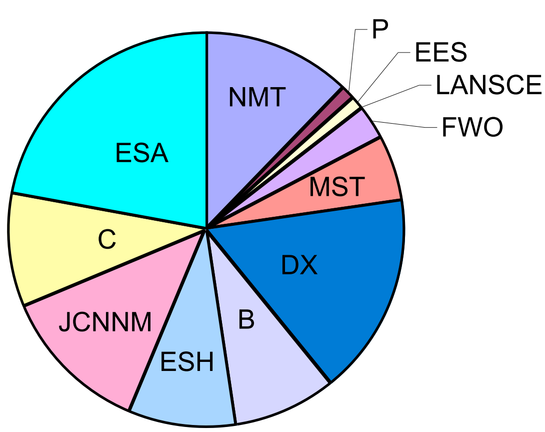


Fig. 5-4. Hazardous waste by division.

5.2. Hazardous Waste Minimization Performance

In a November 12, 1999, memorandum, the Secretary of Energy established a 2005 goal to reduce hazardous waste from routine operations by 90%, using a calendar year (CY)93 baseline. The Laboratory's CY93 baseline quantity was 307,000 kg; therefore, the FY05 target becomes 30,700 kg.

The trend over the last several years has been very good; the Laboratory is projected to dispose of 16,523 kg (16.5 tonnes) of hazardous waste in FY02. The Laboratory's performance in hazardous waste generation is shown in Fig. 5-5.

It is estimated that 1010 kg of unused, unspent chemicals will be disposed of in FY02, as compared with 15,000 kg in FY01 and 8000 kg in FY00. This decrease is attributed to a continuing emphasis on reducing chemical inventories.

5.3. Waste Stream Analysis

Hazardous waste is derived from hazardous materials/chemicals purchased, used, and disposed of; hazardous materials already resident at the Laboratory that are disposed of as part of equipment replacement, facility replacement, or facility decommissioning; and water contaminated with hazardous materials. After it is declared waste, hazardous waste is described (assayed if necessary), labeled, and collected at less-than-90-day storage areas. This waste then is either directly shipped to offsite TSDFs or transshipped to Area L, Technical Area (TA)-54, from which it subsequently will be shipped to an offsite TSDF. ER project waste typically is shipped directly from ER sites to commercial TSDFs. Spent research and production chemicals make up the largest number of hazardous waste items; however, they account for only a small fraction of the total hazardous waste volume. The ER project is the largest hazardous waste generator on site, accounting for over 95% of all hazardous waste. The Laboratory spent a total of $1,900,000 managing newly generated hazardous waste in FY02.

The largest waste streams in the hazardous waste category for FY02 are described in the following list. These wastes are treated/disposed of off site. This list includes both routine and nonroutine wastes but excludes EM-ER wastes. The Laboratory also has high explosives (HE) and HE water wastes that are treated on site; these are not included below.

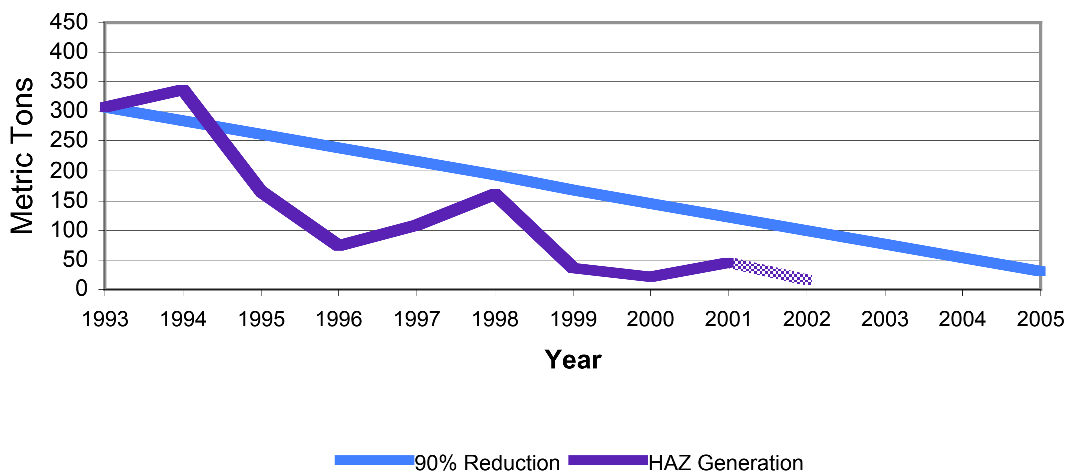


Fig. 5-5. Routine hazardous waste generation compared with the Department of Energy's (DOE's) FY05 goal.

Many of the largest waste streams in FY01 were reduced or eliminated in FY02 as a result of aggressive waste minimization activities. The waste streams most affected were routine oil- and petroleum-contaminated materials, ferric chloride, various contaminated liquids (routine and nonroutine), corrosives, photochemicals, ash, solvents, and mercury. Many of these previously large waste streams now contain no routine waste; even the routine waste has been reduced.

Ash. A persistent component of the hazardous waste stream is ash collected from the various Laboratory burn grounds.

Unused/Unspent Chemicals. This waste stream was by far the largest routine waste stream for FY01 and constituted more than 30% of the total routine hazardous waste disposed of. It consists primarily of unopened or unused research and production chemicals, many in their original containers. In FY02, the waste stream was greatly reduced because of increased attention to chemical inventories and prior-year cleanout.

Biomedical Waste. This waste stream consists primarily of blood, blood-contaminated items, and used sharps.

Process Waste from Hydrolysis. This waste is generated in the course of explosives hydrolysis.

NAOH Stripper. Sodium hydroxide is widely used as a stripping agent and most of the spent NaOH waste is used to neutralize acid wastes. In prior years this waste stream has been quite large.

Solvents. Solvents are used widely at the Laboratory in research, maintenance, and production operations. They constitute the single largest number of items sent for disposal each year and are persistent from year to year. The largest waste streams in the routine hazardous waste category for FY02 are shown in Fig. 5-6.

Laboratory Trash. This waste stream consists of contaminated wipes, glassware and laboratory equipment.

The waste streams are shown as a percent of total hazardous waste in Fig. 5-6. This chart excludes EM-ER waste, nonroutine waste, and sanitary sludge with legacy contamination. Clearly not all the waste is accounted for by these waste streams. About half the hazardous waste is composed of very many small items such as lab equipment, contaminated cans, containers and miscellaneous chemicals.

5.4. Improvement Projects

The following projects were identified as potential corrective measures for the hazardous waste type. These projects are divided into three categories: (1) projects completed in the last year, (2) projects currently funded and ongoing, and (3) proposed projects that are unfunded. Projects are characterized further by type: source reduction (SR), sort and segregate (SS), reuse/recycle (RR), treatment (T), or disposal (D).

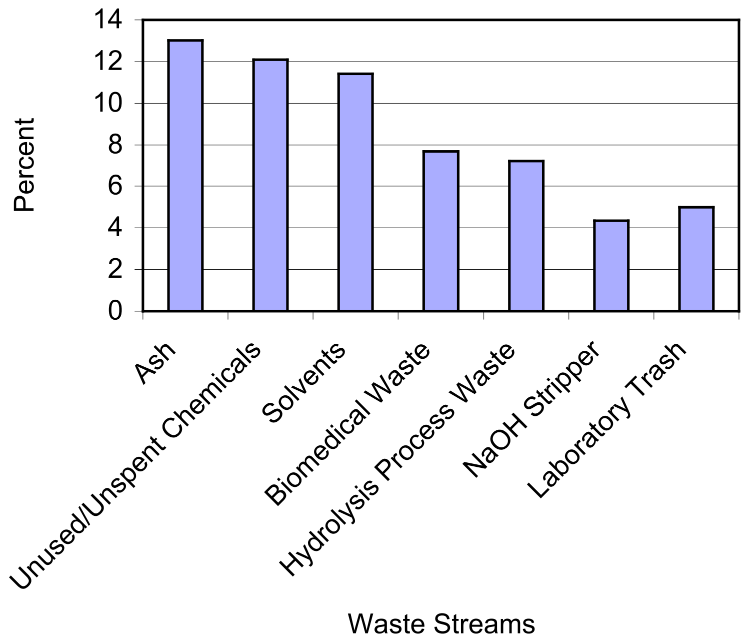


Fig. 5-6. FY02 routine hazardous waste stream.

5.4.1. Completed Projects

These projects have been completed and/or implemented in the last year.

Hydraulic Systems Improvements (SR). Johnson Controls Northern New Mexico (JCNNM) is redesigning hydraulic couplings on backhoes and other machinery to reduce the likelihood of coupling failure and resulting oil spills. Oil spill cleanup generates State waste. JCNNM replaced the oldest Pakmaster (trash compacting truck), which has had frequent hydraulic line failures. (These improvements are based on a Green Zia Tools assessment conducted by JCNNM in FY00.)

Ferric Chloride Recycle/Disposition (RR). Ferric chloride suppliers will pick up spent ferric chloride solution for recycle. This action will reduce hazardous waste by ~4000 kg.

Recover and Recycle Silver from Photochemical Fluids (RR). A vendor will be identified and a contract will be placed to recover silver from photochemical fluids. This process will allow recycling of the silver.

Initiate Puncture and Recycle of Aerosol Cans (RR). Aerosol propellants are normally hazardous substances. Aerosol cans cannot be recycled if they contain residual propellant. By puncturing the cans and recovering the propellant, the cans can be recycled.

5.4.2. Ongoing Projects

These projects have been funded and currently are being executed. In some cases, the remedies are administrative actions that have been taken to resolve conflicting goals. Hazardous waste reduction projects are funded by the Defense Programs (DP)-funded Pollution Prevention Program, Generator Set-Aside Fee (GSAF) Program, and mission programs.

Pyroclean Oven for the Chemistry (C) Division, Actinide Chemistry Group (C-ACT) Organic Synthesis Laboratory. Organic synthesis laboratories generate a large amount of glassware covered with organic residues. Solvent and oxidizing acids are used to clean this glassware, generating hazardous waste that requires disposal. Besides the generation of waste, this process is time consuming and expensive. This project will fund the purchase and installation of a pyroclean oven to eliminate the hazardous waste associated with glassware cleaning and to decrease labor expenses. The pyroclean oven uses high temperature to remove the organic residues. The organic vapors then are destroyed in a catalytic oxidizer system located on the oven exhaust.

C-ACT Chemical Pharmacy. C-ACT has one of the largest chemical inventories at the Laboratory. Maintenance of large chemical inventories is time consuming and expensive. Large inventories are the result of multiple laboratories located at different areas and the need to maintain a large enough variety of chemicals to respond to different R&D and analytical requests in a timely manner. Currently, individual laboratory owners maintain this large inventory with little coordination between them. This multiple maintenance of chemical inventory results in duplications within the overall chemical inventory. In addition, without coordination, sharing and reuse of chemicals between laboratory owners do not occur. The net result, the quantity and number of unused, unspent, or surplus chemicals, is increased dramatically. By consolidating the chemical management and procurement into one unified system, duplications and the quantity and number of these chemicals can be reduced dramatically. C-ACT estimates that consolidation easily will result in a 50% waste reduction. The purpose of this project is to set up a consolidated chemical management/procurement system for C-ACT. If successful, C-ACT will work with division management to expand this system to incorporate all of C-Division's chemical management needs.

Los Alamos Neutron Science Center Experiment (LANSCE) Lead Waste Minimization and Recycle. At TA-53, LANSCE produces a large quantity of gamma emitting isotopes, which necessitates the use of lead shielding. As a result, LANSCE currently maintains the largest stockpile of lead at the Laboratory. The lead stockpile is located in MPF-621 and is accessed routinely for various experiments. The building is very old, in poor condition, and inadequate for lead storage. LANSCE management proposes moving the current stockpile to another, more suitable storage location and cleaning up the existing building to eliminate potential environmental impacts.

Cost and Waste Reduction in Ultra-Trace Cleaning Operation. This project will fund the purchase, installation, and evaluation of an automated system for the acid cleaning of labware. Current methods for cleaning labware for ultra-trace metals analyses involve repeated boiling in nitric and hydrochloric acid. A commercial supplier of an automated system that recycles the acid using a sub-boiling process has been identified.

C Division estimates that it could reduce both nitric acid and hydrochloric acid consumption by as much as 100 L of each per year. In addition, this system would reduce the possibility of spills associated with the daily handling and disposal of relatively large amounts of cleaning acid. C Division also would save approximately $10k per year in full-time-employee costs due to process automation.

Nonhazardous Resuspension Solution for DNA Sequencing. The Genome Project at Bioscience Division, TA-43, has started a new phase of genomic sequencing of microorganisms. Methods involve high-throughput techniques for DNA sequencing. Formamide, a hazardous chemical, is the standard solution for resuspending the DNA before loading it onto the DNA analyzer. This project will demonstrate whether the formamide can be replaced with a water-based resuspension solution; this process would provide a sequence data quality comparable or superior to that obtained with the formamide solution. A water-based resuspension solution will allow us to switch to nonhazardous waste disposal of the plastics used to hold the DNA samples and will completely eliminate daily exposure of the machine operator to the formamide.

Processing of Pentaerythritol Tetranitrate (PETN) with Supercritical CO_2. Group DX-2 PETN production operations generate 250 gal. of hazardous waste annually. This waste consists of 90 lb of acetone, 226 lb of ethanol, and ~1700 lb of water. Currently, this waste is sent to ESA Division for destruction at the burn pad. However, in a recent letter to the Laboratory Director, NMED expressed its concerns about the air emissions at the ESA Division facility. It is uncertain if this disposal path will be available in the future. Without this pathway, DX Division will have to dispose of this waste as hazardous waste at a cost of $10,000/yr ($6000 in disposal costs, $4000 in waste management costs). Under separate funding, DX Division already has developed a process to produce PETN using supercritical carbon dioxide as the solvent, thus completely eliminating the generation of a hazardous waste stream. This project will scale up this process to production levels in order to produce 5.5 lb of PETN annually.

Bio-Based Hydraulic Oil (SR). JCNNM is converting Laboratory heavy equipment to use bio-based hydraulic oils. These oils are not regulated as hazardous waste; consequently, oil spills and spill cleanup will become sanitary waste.

Oil Waste Reduction (SR). The continuing expansion of ongoing programs is expected to reduce this waste stream significantly over the next 2 to 3 years.

Sitewide Process Neutralization (T). Currently, spent acidic or basic chemicals are disposed of as waste. Because of their corrosive nature, these chemicals are RCRA hazardous waste. By implementing a simple neutralization step at the end of the processing cycle, many kilograms of hazardous waste (in the form of corrosives) could be converted to less-hazardous State waste. Neutralized waste should be easier to recycle than the original corrosives.

5.4.3. Proposed Projects

These projects or actions have been proposed to (1) allow further reduction in the routine hazardous waste stream; (2) improve operational efficiency; and (3) in the case of fixing finely divided powders, increase safety. Many projects currently are unfunded. If implemented, these projects will provide an additional margin against unexpected and unplanned increases in waste generation. The projects are presented in the order of the waste streams they are intended to reduce, with the largest streams first.

DX-Division Wastewater Treatment (T). DX Division generates 5000 to 15,000 gal. annually of HE wastewater that does not meet the HE wastewater WAC. This water must be disposed of as hazardous waste. An FY02 project to evaluate wet oxidation methodologies for reusing this wastewater has been successful. Funds are needed to proceed with Phase II of this project, which is implementation of the wastewater reuse system at the DX-2 facility. The wastewater system will consist of a small transportable heating building (8 ft x 10 ft) located near the three DX-2 wastewater tanks. An ultraviolet oxidation system will be installed within this small transportable and will be connected to the wastewater tanks. Treated water will flow from between the wastewater tanks into one tank designated for reuse. Upon successful completion of this project, the treatment system will be fully capable of supplying treated wastewater for reuse within the facility for glassware cleaning, etc.

Unit TA-16-388 Burn-Ground Upgrade (T). This project will increase operational flexibility and safety controls of ESA Division, Weapon Materials and Manufacturing Group (ESA-WMM)-permitted disposal treatment operations at Unit TA-16-388 of the burn grounds. This increased flexibility will allow ESA-WMM to close three RCRA-permitted disposal sites at the burn grounds. The RCRA-permitted sites to be closed are Units TA-16-401, TA-16-406, and TA-16-399. This closure reduces the number of permitted RCRA treatment sites at the burn grounds from four to one. Elimination of HE burning operations in the filter vessels (at Units TA-16-401 and 406) also will eliminate the use of a large heated-air unit used to dry the HE before burning. However, the most important reason for moving HE burning operations off Units 401 and 406 and onto Unit 388 is for safety considerations. Large amounts of dried HE no longer will remain in a vessel, thus eliminating any risk of detonation before burning.

Onsite Analyzer for Waste Reduction and Minimization (SR). Sample analysis has been running routinely for many years throughout the Laboratory. For elemental determinations, laboratory-based instruments such as inductively coupled plasma source emission spectrometry has been applied frequently in environmental safety and health surveillance monitoring, waste management plant operation, and miscellaneous industrial hygiene samples. During these sample analysis processes, significant labor work and chemical reagents are required to achieve necessary results, including sample collection, storage, and transportation. These reagents then are sent to the Laboratory for analysis. Most samples also must be digested chemically with nitric or some other acids before they can be sent to the instrument. In addition, a rinse solution containing 1% to 10% nitric acid frequently is used during the analysis process. All of these processes generate a significant amount of waste. C Division proposes building a plasma-source-based, field-portable spectrometer for onsite water or waste-stream sample analysis, which can eliminate sample preparation/digestion processes and can significantly reduce or eliminate waste generated during routine laboratory analysis. Such a device will be installed in the TA-50 waste treatment plant for onsite, real-time monitoring of recycling water quality.

This proposed analyzer should simplify the analytical procedure in waste treatment monitoring, provide timely feedback information to management, and reduce or eliminate waste generated during routine laboratory analysis. Operational benefits also include less labor required, fewer or no chemical reagents used, and potentially reduced air and water effluents.

If these projects are implemented, the Laboratory should see a significant reduction in hazardous waste. Because these projects address the routine hazardous waste stream components, the effects will be seen there.

Successful implementation of these projects will reduce the hazardous waste stream to a total value below the FY05 goal of 31 tonnes.

REFERENCES

5-1. United States Department of Energy, "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory," United States Department of Energy document DOE/EIS-0238 (January 1999).

5-2. United States Department of Energy, "Mitigation Action Plan for the Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory," United States Department of Energy document DOE/EIS-0238 (September 1999).

5-3. "General Waste Management Laboratory Implementing Requirement (LIR)," Los Alamos National Laboratory implementation requirement LIR404-00-02.2 (issue date: November 1, 1998, revised date: October 6, 1999).

5-4. "Hazardous Waste Management LIR—Laboratory Implementation Requirements," Los Alamos National Laboratory implementation requirement LIR404-00-03.0 (effective date: December 16, 1996).

5-5. Los Alamos National Laboratory Hazardous Waste Permit NM0890010515-1 (1989).

6.0. SOLID SANITARY WASTE

6.1. Introduction

Most material brought into Los Alamos National Laboratory (the Laboratory) will leave as solid sanitary waste if it cannot be sold for reuse, salvage, or recycle. Sanitary waste is excess material that is neither radioactive nor hazardous and that can be disposed of in the Department of Energy (DOE)-owned, Los Alamos County-operated landfill (County landfill, or landfill) according to the waste acceptance criteria (WAC) of that landfill and the State of New Mexico Solid Waste Act and regulations. Solid sanitary waste includes paper, cardboard, office supplies and furniture, food waste, wood, brush, and construction/demolition waste. Figure 6-1 is the process map for sanitary waste generation at the Laboratory. Facility Waste Operations–Solid Waste Operations (FWO-SWO) is responsible for collecting, recycling, and managing the Laboratory's solid sanitary waste stream.

Materials come into the Laboratory as required by Laboratory operations. Mail includes both internally and externally generated mail. Many items, such as copiers, computers, office supplies, experimental apparatus, and furniture, are procured as part of the Laboratory operations. Food is brought into the Laboratory as part of the cafeteria operations and from homes and restaurants. Materials and substances, such as building materials and chemicals, are needed in construction, maintenance, research, and infrastructure operations.

After items either have reached the end of their useful life or are no longer needed, they are discarded. Many are salvaged or placed in recycle bins. Salvaged items can be recycled either internally or externally. Some items are discarded and end up in dumpsters. These items go to the Materials Recovery Facility (MRF), which is operated by FWO-SWO. At the MRF, items that can be recycled are segregated from the dumpster waste and sent to recycle. Items that cannot be recycled are sent to the landfill. Some items, such as firing-site glass and nonrecyclable construction waste, go

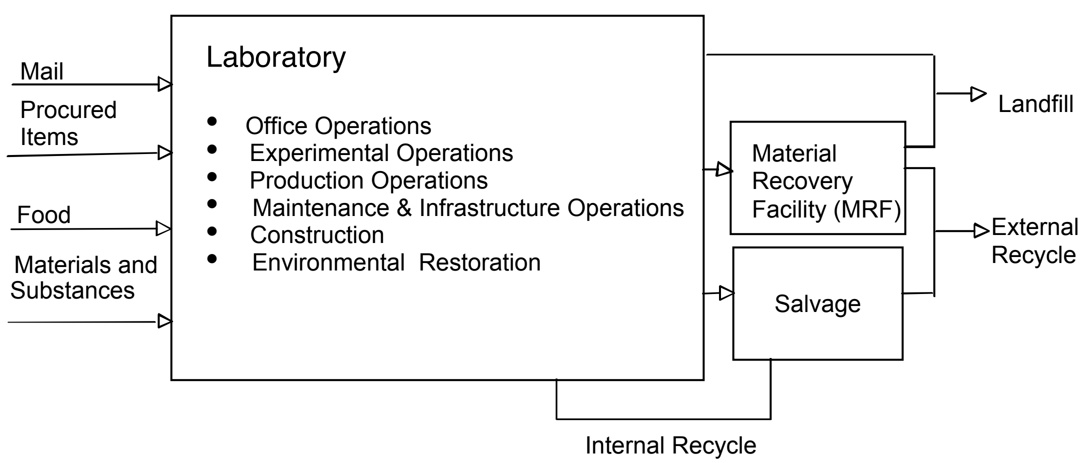


Fig. 6-1. Top-level sanitary waste process map.

directly to the landfill. Thus, virtually every nonradioactive, nonhazardous item brought to the Laboratory eventually is either recycled or buried at the landfill. Reducing the volume of sanitary waste being buried at the landfill requires either reducing the quantity of materials flowing into the Laboratory (source reduction) or increasing the quantity of materials recycled.

The Laboratory generated 10,424 tonnes of sanitary waste in fiscal-year (FY) 02. Of this total, 7387 tonnes was recycled, including 5750 tonnes of nonroutine construction wastes and 1637 tonnes of routine sanitary wastes. These wastes comprised paper, cardboard, metal, wood pallets, and plastic. The remaining wastes were disposed of, including 1233 tonnes of nonroutine construction wastes and 1822 tonnes of routine sanitary waste, the vast majority of which came from Laboratory dumpsters.

Figure 6-2 displays the relative volumes of construction, routine, and recycle materials in the sanitary waste stream.

The routine sanitary waste stream has three components: dumpster waste, waste diverted from the hazardous waste stream by FWO-SWO at Technical Area (TA)-54, and other waste. The dumpster waste is composed of anything that is discarded in desk-side trashcans, trash receptacles, or dumpsters. The SWO waste is nonhazardous solid waste that is generated as process waste and is managed at TA-54.

Dumpster waste is the largest component of routine sanitary waste and includes virtually all discarded items that are not initially recycled or are not recovered at the MRF. The major constituents of the dumpster waste stream are cardboard, paper, food waste, wood, plastic, Styrofoam, glass, and metals. Figure 6-3 shows the relative weights of the components of the routine sanitary waste stream.

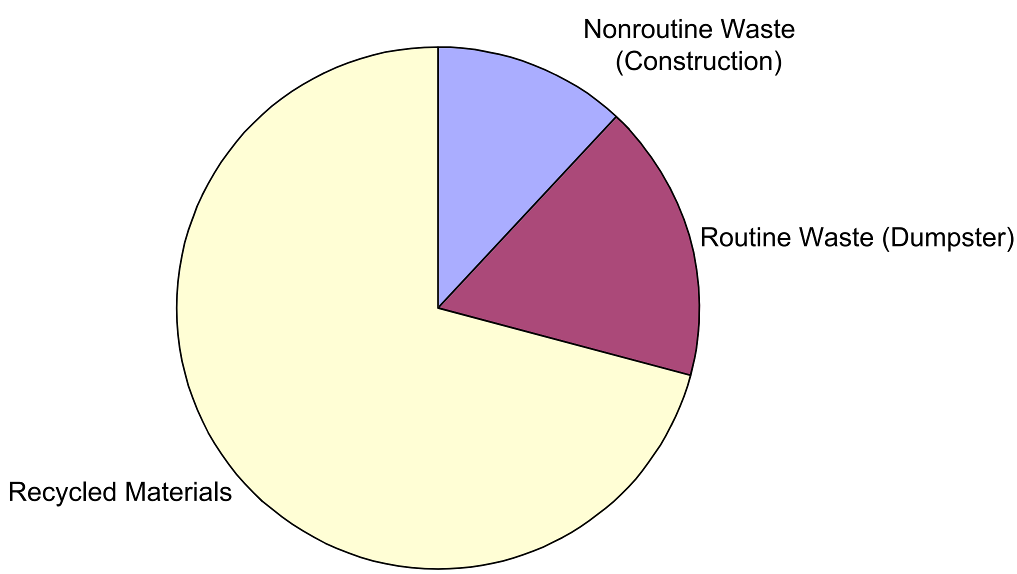


Fig. 6-2. Sanitary waste disposal and recycling.

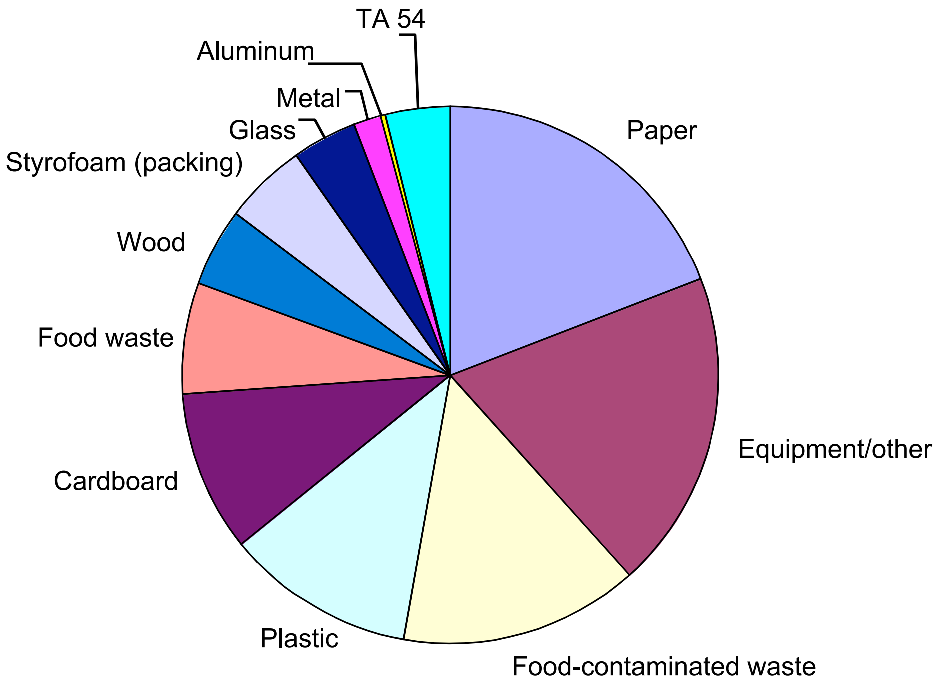


Fig. 6-3. Routine sanitary waste by type.

6.2. Sanitary Waste Minimization Performance

The DOE has implemented goals for waste minimization. The DOE proposes that solid sanitary waste generated from routine operations be reduced by 75% by 2005 and by 80% by 2010, using calendar-year (CY)93 as the baseline. Routine waste is defined as waste generated by any type of production, analytical, and/or research and development (R&D) laboratory operations; work for others; and any periodic and recurring or ongoing work. The Laboratory's performance toward this goal is shown in Fig. 6-4. (Total yearly waste generation is calculated as the sum of disposed waste and recycled volumes—only the yearly amount disposed of is represented in the graph.)

The Laboratory is working with the DOE to develop a modified sanitary waste reduction goal of 50% rather than 75% by 2005. The Laboratory has made good progress to date in avoiding and diverting sanitary waste since the baseline year of 1993; sanitary waste generation has decreased by 976 tonnes since 1993.

The Laboratory's mission has increased since 1993, with an associated 14% staffing increase in FY01. Yet in spite of the staffing increases and increase in mission, the waste generation-per-person rate has decreased from 265 kg/person/year in 1993 to 163 kg/person/year in 2001, resulting in a 39% decrease in waste generation. This reduction is the outcome of aggressive waste minimization programs that include recycling of white paper, junk mail, colored office paper, catalogs, cardboard, and metal and source reduction efforts such as the Stop Mail program. Most major sanitary waste streams at the Laboratory have a recycling pathway.

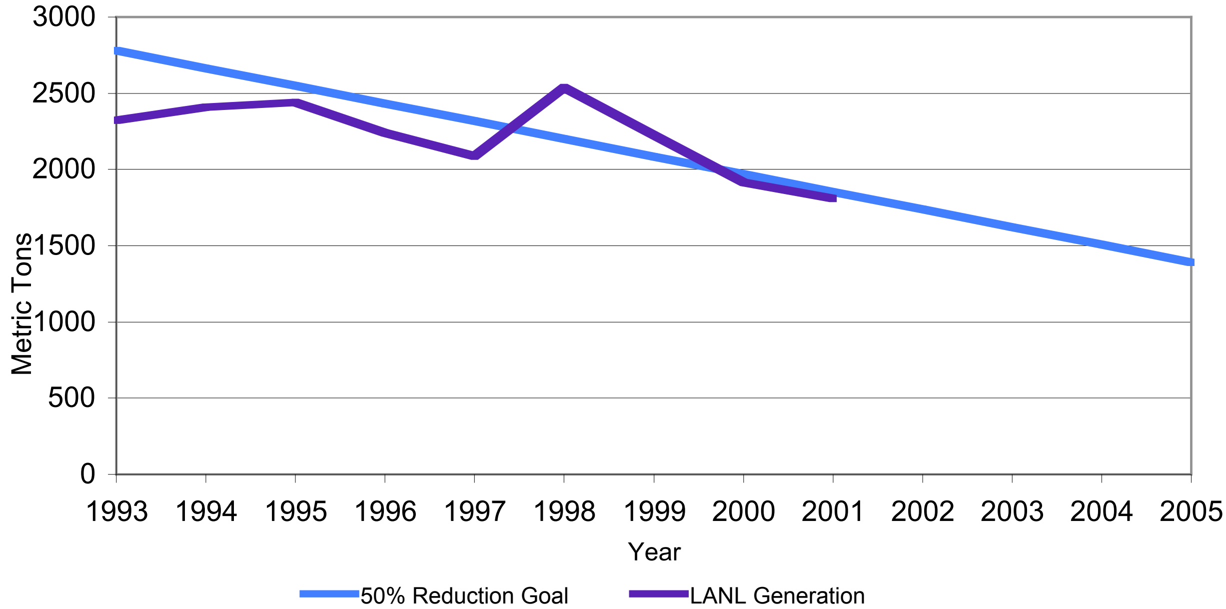


Fig. 6-4. Routine sanitary waste sent to the County landfill.

Laboratory Director John Browne announced during his 2002 State of the Laboratory speech that the Laboratory is adding 1000 new jobs. The addition of new staff will result in an increase of sanitary waste from office areas as well as from expanded operations. The ability of the Laboratory to reduce the waste-per-capita rate is limited because recycling programs already have been developed for most waste streams except food waste.

The planned staff increase will add 163 tonnes to the waste stream for a projected waste generation total of 2157 tonnes with no additional intervention. This increased rate of generation will require that the Laboratory reduce waste generation by 767 tonnes to meet the 50% goal and 1462 tonnes to meet the 75% reduction goal.

The Laboratory can meet the 50% sanitary waste reduction goal by 2005 through expanded recycling and source reduction efforts. A 75% sanitary waste reduction goal would require that the Laboratory employ waste management technologies rather than source reduction and recycling programs. These technologies include waste-to-fuel conversion technology, which is not a proven technology, and digester technologies that may cost millions of dollars to install and operate.

In FY03, management responsibility of the recycling program was moved to FWO-SWO. FWO-SWO has developed a fully integrated waste management and recycling program to improve recycling and diversion rates to meet the DOE's 2005 goal of 50% sanitary waste reduction and to reduce overall operating costs.

The DOE also requires that 45% of the sanitary waste from all operations (both routine and nonroutine) be recycled by 2005 and that 50% of the waste be recycled by 2010. The recycling rate is calculated as

$$\frac{\text{amount recycled}}{\text{(amount recycled) + (amount disposed of)}} = \text{overall recycling rate.}$$

The Laboratory's performance toward this goal for sanitary waste is shown in Fig. 6-5. The recycle of total (routine + nonroutine) sanitary waste currently stands at 70%.

6.3. Waste Stream Analysis

Practically every item that enters the Laboratory (other than radioactive material, hazardous material, and materials that become radioactive) leaves the Laboratory in the sanitary waste stream at the end of its useful life. At that point, it is recycled, reused (salvaged), or buried in the landfill. Materials disposed of include construction waste, food and food-contaminated wastes, paper products, glass, and Styrofoam.

The waste stream analysis addresses wastes that were not recycled during FY02. Expanded recycling and source reduction initiatives are being instituted to reduce these waste streams further.

6.3.1. Nonroutine Waste Streams

Construction/Demolition Waste (1233 tonnes sent for disposal). The largest sanitary waste stream at the Laboratory is the construction/demolition waste stream. Construction/demolition waste is generated during the Laboratory's projects to build new facilities, upgrade existing facilities, or demolish facilities that are no longer

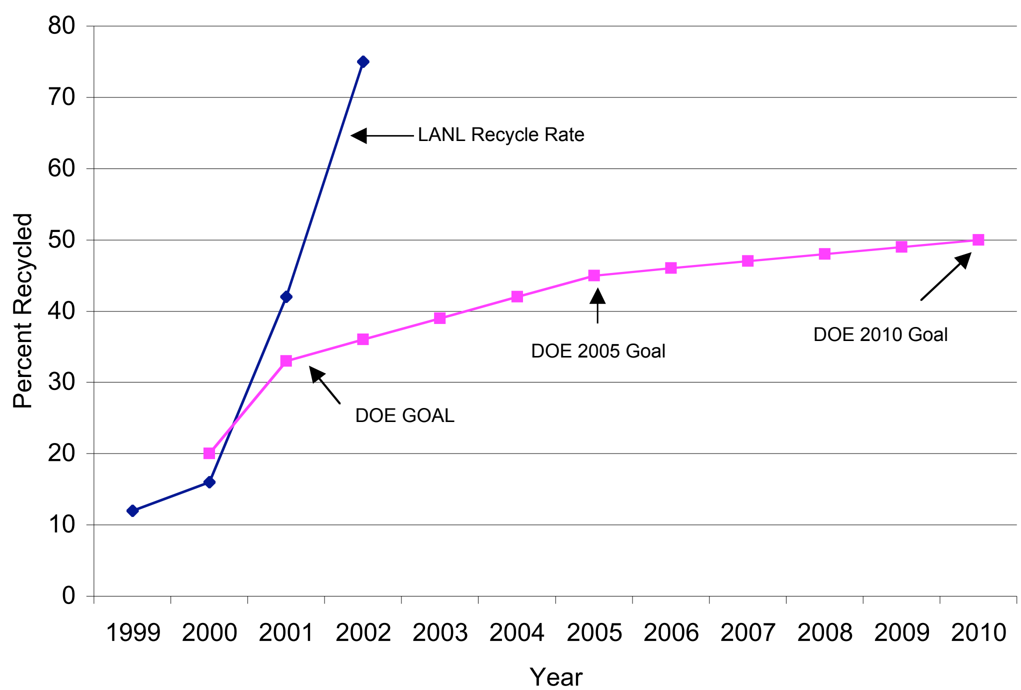


Fig. 6-5. Laboratory routine sanitary waste recycling rate.

needed. Construction/demolition projects require that raw materials and equipment be brought onto the site, along with utilities (especially water). The waste generated by these projects is varied and consists primarily of dirt, concrete, asphalt, some wood items, and various metal objects; the three largest components of this waste are used asphalt, concrete rubble, and dirt. This waste stream is growing and will continue to do so as planned new construction and renovation projects begin. Before May 1998, these materials were reused as fill to construct a land bridge between two areas of the Laboratory; however, that activity was halted because of environmental and regulatory issues. Recycling programs were established for concrete, asphalt, dirt, and brush in FY01. These recycling programs were deployed fully in FY02 and diverted 5750 tonnes of construction waste, with only 1233 tonnes of construction waste sent for disposal.

6.3.2. Routine Waste Streams

Cardboard (174 tonnes sent for disposal). Cardboard enters the Laboratory in one of two ways: as packaging materials or as newly purchased moving boxes. Some of the cardboard, particularly cardboard moving boxes, is recycled for reuse routinely. Other cardboard is discarded to either the dedicated cardboard collection roll-offs or the trash dumpsters. Dumpster trash is taken to the MRF and sorted, and recyclable cardboard is recovered. Wet or food-contaminated cardboard is sent to the landfill for disposal.

Paper Products (347 tonnes sent for disposal). The Laboratory purchases ~583 tonnes of paper products each year. These products are used in a variety of ways, but mostly in offices for printing, copying, faxing, and other office support uses. Paper is used to produce unclassified, classified, and sensitive documents, and each type has a different path to disposal. Unclassified paper products normally are disposed of in either green desk-side bins, which are taken directly to recycle, or in trash bins. Approximately 120 tonnes of unclassified materials is sent to storage or to archiving. This material is held in storage for varying periods before it is disposed of. Some unclassified material may be distributed to radiological control areas (RCAs), where it is subject to radioactive contamination and disposal as low-level waste (LLW). Uncontaminated paper from RCAs may be disposed of in Green Is Clean (GIC) bins and sent to be characterized and recycled. Every year the Laboratory receives and distributes over 400 tonnes of mail. This mail includes junk and business mail, catalogs, phone directories, and various documents. The Laboratory distributes mail, including internally generated mail. Most of this material can be recycled after use. Publications such as catalogs and directories that are bound with glue must have the bindings sheared off before the paper is recycled; the bindings then are sent to the landfill for disposal. The paper-recycling program diverted 191 tonnes of white paper and 109 tonnes of mixed office paper in FY02. Classified material may not be disposed of unless it has been security (cross-cut) shredded. New programs in FY02 now are recycling shredded paper that formerly was disposed of.

Food and Food-Contaminated Materials (382 tonnes sent for disposal). Food products enter the Laboratory waste streams either through food service from one of the four cafeterias or from food brought into the Laboratory from off site. The total food waste stream is estimated to be ~122 tonnes per year. All of the food and food-contaminated wastes generated at the Laboratory are sent to the landfill. Currently, no composting pathways are available for food and food-contaminated wastes. However, proposed changes in the NMED solid waste regulations may encourage food composting and other recycling pathways may become available. Food waste from trash bins and kitchen areas around the Laboratory is particularly intractable because it cannot be collected easily and contaminates other recyclable materials with which it comes into contact as a result of compaction during collection. Approximately 260 tonnes of paper, cardboard, Styrofoam, plastic, and other materials is rendered unrecyclable due to food contamination through commingling of food and other wastes in the trash.

Plastics (208 tonnes sent for disposal). Plastics and foam are used for many purposes at the Laboratory and constitute the third largest component of dumpster waste. The waste stream consists primarily of food/beverage containers, shrink-wrap, plastic bags, and packaging materials. A beverage plastics recycling program was instituted in FY02 and diverted 4 tonnes of plastics. A recycling pathway for mixed bulk plastics was available in FY02 and diverted 20 tonnes of plastics. The material was being used to manufacture plasphalt as paving material. However, the New Mexico Highway Department did not approve plasphalt as an accepted paving material in spite of the successful pilot; thus, this recycle pathway is no longer available.

Wood (87 tonnes sent for disposal). The Laboratory produces waste wood through the discarding of wooden pallets and clearing areas of vegetation. The wood contained in dumpsters also includes a significant quantity of construction wood waste that has been disposed of improperly. To the extent possible, brush and wood waste are recycled for the Laboratory by Los Alamos County. A pilot program to recycle pallets was initiated in FY02, and 187 tonnes of pallets was diverted.

Glass (69 tonnes sent for disposal). Glass products enter the Laboratory either as purchased items (e.g., beakers, flasks, and pipettes) or as containers. Although many chemicals are purchased in glass bottles, a significant source of glass is beverage containers, either purchased through the food services on site or brought in from outside the Laboratory and disposed of on site. Limited opportunities exist for recycling this waste stream because of a lack of market demand and high transportation costs. Glass currently is disposed of at the landfill. A pilot program to recycle glass was initiated in FY02 and will be continued. It is estimated that this pilot will divert 30 tonnes from the waste stream.

Aluminum Cans (5 tonnes sent for disposal). An estimated 5 tonnes of used aluminum cans is disposed of each year; aluminum cans that are disposed of are commingled with trash and cannot be removed safely at the MRF. In FY02, 4 tonnes of aluminum cans was recycled.

TA-54 Routine Sanitary Waste (28 tonnes sent for disposal). The Laboratory generates ~28 tonnes of nonhazardous, nonregulated sanitary waste from Laboratory research processes. These wastes are generated from various processes.

Other Waste (347 tonnes sent for disposal). A variety of materials is disposed of, including unsalvageable and unrecyclable equipment, filters, leaves, glass, metal pieces, office supplies, furniture, and other materials that cannot be recovered safely or economically.

6.4. Improvement Projects

The projects intended to mitigate the effects of sanitary waste on the environment are shown in the following subsections. The projects are classified as completed, ongoing, or unfunded.

6.4.1. Completed Projects

The following projects have been completed; however, in some cases, there are follow-on activities.

Material Recovery Facility. The Laboratory completed the construction and began initial operation of an MRF to recover recyclable items from trash dumpsters. Dumpsters are emptied and their contents sorted at the MRF. This operation results in the recovery of ~40% of waste that would otherwise be disposed of. The purchase of a baler has increased the efficiency of the MRF operation greatly.

Cardboard Recycle. For several years, the Laboratory has been expanding its cardboard recycle program. Beginning in FY97, the Laboratory began purchasing roll-offs for facilities across the site. This action has greatly increased the volume of cardboard going to recycle. In addition, the Laboratory began recovering cardboard at the MRF and baling it in FY00, which has improved the ease of recycling. The total amount of cardboard recycled in FY02 was 262 tonnes, down from a total of 319 tonnes collected in FY01 due to closure of the MRF for upgrades. It is estimated that ~150 tonnes was collected through the cardboard recycle program, and it was estimated that 112 tonnes was recovered through the MRF.

Paper and Document Recycle. The Laboratory recycles paper, mail, and publications through the following three programs.

- Green Desk-Side Bin Recycle. Most unclassified white paper can be deposited in green desk-side bins for recycle. Sensitive materials are shredded before being recycled as unclassified waste. In FY02, ~191 tonnes of white paper was recycled.

- MS A1000. Junk mail, books, transparencies, newsprint (newspapers), magazines, flyers, brochures, catalogs, binders, colored paper, and folders are recycled at the Laboratory by sending unwanted materials to MS A1000. Phone books are recycled annually at MS A1000. This program won a White House Closing the Circle Award in FY00. Approximately 109 tonnes of sanitary waste is recycled through the MS A1000 program each year.

- J568—"Stop Mail." MS A1000 provides a mechanism for recycling unwanted paper or documents, but the "Stop Mail" Program provides a mechanism for stopping unwanted mail from ever entering the mail system. Employees receiving unwanted mail at the Laboratory may send that mail to MS J568 to be removed from mailing lists.

Concrete Crushing. The Laboratory conducted a pilot project to establish a concrete crushing and reuse system in FY01. The FY01 pilot program diverted 730 tonnes of concrete and asphalt to recycle. The crushing and reuse program was deployed fully in FY02, and 3875 tonnes has been recycled.

Construction Debris Inspection/Recycle. A program has been implemented to inspect all construction debris for recyclable content. Sorting and segregation of reusable items occurs at the construction site before the debris is loaded. Trucks containing construction debris then are dispatched to the salvage yard for inspection. If the trucks are found to contain recyclable or reusable items, those items are removed.

Dirt Recycling. All uncontaminated dirt is sent off site to be used as fill material. Currently, dirt is being sent to the Los Alamos County Golf Course to be used as fill.

Brush Recycling. Brush and branches from construction projects are sent to the Los Alamos County Landfill, where they are chipped and distributed as mulch to County residents.

Salvage and Reuse. Items that have been replaced or are no longer needed but have some useful life left can be reused within the Laboratory through the Laboratory salvage program or sold to individuals, organizations, or vendors off site for recycling.

Metal Recycle. Metals and scrap wire are recycled through FWO-SWO. If large amounts of metal or wire are expected to be generated at a site, the site responsible for generating this waste may arrange for a scrap metal collection bin to be placed at its site. All bins are serviced by FWO-SWO, resulting in quicker service and better customer service. Containers are picked up by the recycler at a centralized staging area. All metal must be clean and suitable for public release (i.e., no radioactive or chemical contamination).

Plastic and Aluminum-Can Recycling. Plastic beverage and food containers, aluminum cans, and bulk plastics from Laboratory operations are collected and sent for recycling. This program was initiated in early FY02. In FY02, 24 tonnes of materials was recycled; however, the plastic recycling service provider for bulk plastics no longer is accepting materials.

6.4.2. Ongoing Projects

These funded projects currently are active. They are categorized as in the previous section.

Paper Use Reduction. An outreach program to encourage the reduction of paper use through double-sided copying and printing will be conducted this year. The pilot will encourage procurement of printers that can print double-sided. Outreach materials and reminders will be distributed to encourage employees to reduce paper use. It is estimated that up to 100 tonnes of paper use will be avoided through this program.

6.4.3. Unfunded Projects and Pilots

These projects have an environmental aspect but currently are unfounded or are being examined.

Sitewide Excess Cleanup. The Laboratory has ~10,000 tonnes of mostly unusable excess equipment stored outdoors. Because this material is exposed to rain and snow, it is polluted significantly with stormwater. In addition, some of the material is flammable and represents a fire hazard if stored near structures or other combustible materials such as grass or trees. The excess material also may serve as a shelter for mice, rats, and other small mammals. An effort to reduce or eliminate this material could reduce the pollution potential dramatically, as well as reduce the fire and health risks.

Styrofoam Recycling. The Laboratory generates ~40 tonnes of Styrofoam as part of its packaging materials. Styrofoam is not a significant waste stream in terms of weight; however, it is volumetrically a significant waste stream in terms of collection, handling, and baling at the MRF. Currently, noncompacted Styrofoam is not recyclable through existing recycling service providers.

A Styrofoam densifier would compact the Styrofoam materials that could be recycled. This process would reduce collection, handling, and baling efforts and could reduce sanitary waste and divert ~40 tonnes of materials from the routine sanitary waste stream. Also, a recycling service provider in Albuquerque may accept some types of Styrofoam; the Laboratory will assess the potential for shipping Styrofoam to Albuquerque.

Composting. Compostable materials include cafeteria food waste and food-contaminated paper or cardboard. Currently, no recycling service providers hold permits for food waste composting. Proposed changes to NMED Solid Waste Management regulations may encourage composting. The Laboratory will monitor the regulatory changes and explore composting options.

Glass Recycling. A pathway for glass recycling has been identified, and glass is being recovered from the MRF and from limited laboratory locations. It is estimated that 30 tonnes of glass will be diverted through this program.

Reusable Wood Pallets: Approximately 100 tonnes of pallets comes through the Just In Time (JIT) system annually. A pilot to require JIT vendors to purchase and use reusable pallets will be conducted in FY03.

Outreach and Education. Recycling pathways are developed for most waste streams. The next step is to conduct an education and awareness campaign to ensure that the Laboratory staff is fully utilizing recycling systems that are available to them. It is estimated that up to 175 tonnes of waste can be diverted through the expanded use of existing systems.

Waste-to-Fuel Conversion Technology. Waste-to-fuel conversion technology has been developed and currently is being piloted. This technology is designed to convert any sanitary waste with British-thermal-unit value into gas that can be used as fuel. The technology produces fuel and minor wastewater and ash waste streams. No air emissions are created. This technology is being piloted in El Paso, Texas.

Waste-to-fuel technology, if viable, could reduce the sanitary waste stream by up to 1500 tonnes per year.

Waste Digester Technology. Digester technology has been deployed at nine sites in the United States. This technology removes organic materials from the sanitary waste stream through a rough digestion process that converts all organic material into compost. The end product is rough compost that can be further cured and used as a soil amendment and as nonorganic materials that are disposed of. The technology would process paper, wood, food, food-contaminated wastes, and cardboard into compost.

The digester technology, used alone, may reduce the sanitary waste stream by half, or ~1000 tonnes. The digester technology, coupled with an active plastic, glass, and metals recycling program, can reduce the sanitary waste stream by 90%.

7.0. WATER USE AND CONSERVATION

7.1. Introduction

The utility system (water, natural gas, and electrical supply) at Los Alamos National Laboratory (the Laboratory) is driven by the demand for electrical energy and by the increasing Laboratory population. As energy requirements increase, the demand for cooling water and the volume of effluent discharged at outfalls increase. Most of the Laboratory's consumption of electrical energy manifests itself as heat that must be removed and dissipated. In fact, ~60% of the Laboratory's water is used in cooling towers. Although the electrical supply can be increased by implementing one or more options, the critical component of the energy/water cycle (i.e., the availability of water) cannot easily be increased.

The Laboratory is targeted to use no more than 30% of the total Los Alamos County water rights, or 542 million gallons per year. Water demand at the Laboratory is projected to grow as a result of new mission requirements. With water conservation projects now being implemented, the Laboratory has sufficient water resources to operate current and planned facilities. If the Laboratory significantly increases operation of present facilities or constructs additional ones, its historical water usage could be exceeded. Although Los Alamos County, which supplies water to the Laboratory, has unused water rights, a significant increase in Laboratory or County water use could exceed current water resources. Consequently, it is in the Laboratory's and the County's best interest to pursue an aggressive, cost-effective, water-conservation and gray-water-reuse program. It is also in their joint interest to develop additional water resources to accommodate future growth. Water use and planning at the Laboratory is the responsibility of the Utilities and Infrastructure group in the Facilities and Waste Operations Division (FWO/UI). This group tracks water use and manages improvements and repairs to the infrastructure that reduce water use at the Laboratory. The newly formed Water Conservation Committee, chaired through FWO Waste Facilities Management (WFM), will represent the Laboratory on all water conservation issues and will have interactions on the Laboratory/University of California (UC) institution, Los Alamos County, the Department of Energy (DOE), and regional, state, and national levels. The Water Conservation Committee provides leadership in two areas. The first is in direction, integration, and coordination to promote responsible stewardship in regard to activities potentially affecting regional water resources. Such activities may include, but are not limited to, understanding the legal bases of Los Alamos County and DOE water rights; reviewing water availability issues related to future DOE and Los Alamos County plans; compiling and maintaining an accurate yearly record of actual water use; developing water use forecasts; anticipating and promoting local, state, and federal water conservation goals and practices; and recommending water conservation technologies. The second area of responsibility is the tracking of and participation in regional water planning initiatives outside of Los Alamos County that may affect water availability and/or use.

The Laboratory used ~446 million gallons of water in fiscal-year (FY)99, 432 million gallons in FY00, 348 million gallons in FY01 and 337 million gallons in FY02. The source of this water is a series of deep wells that draws water from the Rio Grande aquifer. Approximately 60% of Laboratory water flows into cooling towers. Without the cooling-tower-water efficiency upgrades, this flow may increase by as much as 70% by 2005 because of new facilities that are being built. Approximately half of this water evaporates; the remainder is released into the Laboratory sanitary system or surrounding canyons through National-Pollutant-Discharge-Elimination-System (NPDES)-permitted outfalls and ground-water (GW) permits. Water is consumed at the Laboratory for many purposes, including cooling-tower uses, operations, domestic use, landscaping, and temperature control. The water eventually is discharged in the form of sanitary water effluent, outfalls, evaporation, or leakage losses. The water supply system and water balance for the Laboratory are shown in Fig. 7-1.

The Laboratory's largest water discharge is to the environment. These discharges are regulated through NPDES, GW, and/or storm water permits.

- Water from cooling towers is discharged directly to NPEDS/GW-permitted outfalls or is sent to the Laboratory sanitary system.
- Water used for industrial and domestic purposes is discharged to the Laboratory's sanitary system if it meets the waste acceptance criteria (WAC).
- Treated sanitary wastewater is discharged either directly to NPDES/GW-permitted outfalls or to cooling towers for reuse.
- Water used in construction processes is discharged to the environment and is regulated by a storm-water permit.

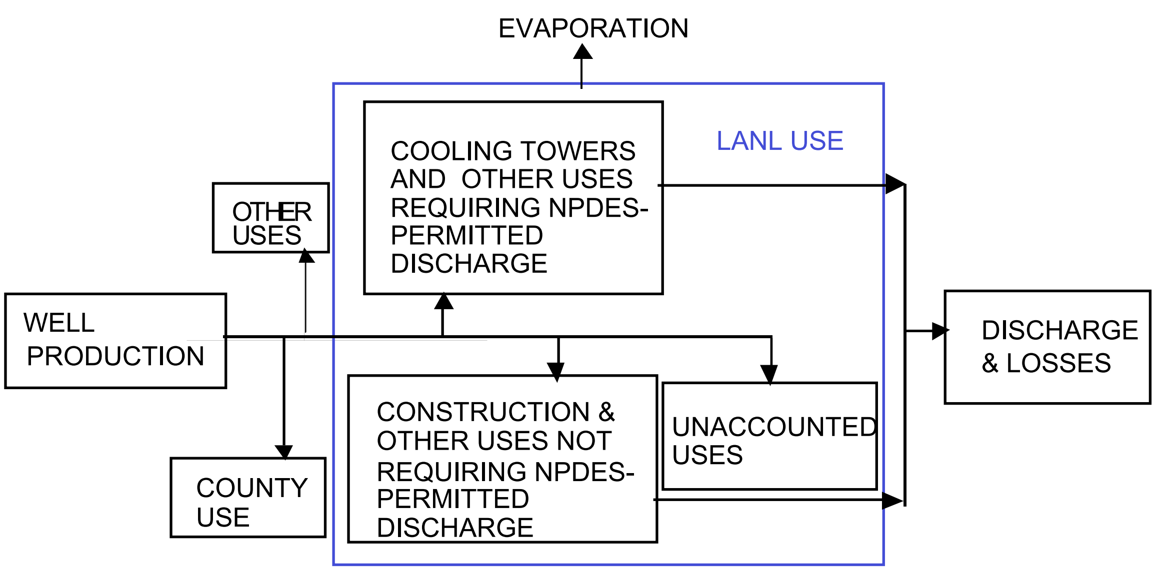


Fig. 7-1. The Laboratory water system.

The only unregulated discharges of water to the environment are leaks and potable water used for landscaping.

The estimated consumption of water by use type at the Laboratory is shown in Fig. 7-2. This distribution of water use is only approximate and is based on a 1997 estimate. By far, the largest use of water at the Laboratory is cooling. The various cooling towers that operate at the Laboratory consume 58% of the total water usage. The largest cooling towers, by volume of water consumed, are the Los Alamos Neutron Science Center Experiment (LANSCE) towers at Technical Area (TA)-53 and the TA-3 towers associated with the large computer facilities [the Central Computing Facility (CCF), the Laboratory Data Communications Center (LDCC), the Nicholas Metropolis Center, and the TA-3 Power Plant]. The major constraint on the cooling-towers' water efficiency is silica concentrations in the cooling water. The concentration of silica in the local GW is ~88 ppm. Because silica will begin to precipitate out and foul heat-exchanger surfaces at ~200 ppm, the concentration must be controlled below that level. Currently, the silica concentration is controlled by operating the towers at 1.5 to 2.0 cycles of concentration. However, the Laboratory is addressing this problem and will deploy water treatment technologies that will allow cooling-tower operation at higher cycles of concentration.

The overall consumption of water at the Laboratory in FY00, FY01, and FY02 is shown by month in Fig. 7-3. The trend in water consumption is somewhat seasonal, with the largest volumes being consumed in the summer. Because this is the period of hottest weather and therefore frequently has the highest electrical demand, water usage at the Laboratory correlates to electrical demand. Because LANSCE is the largest single consumer of electrical energy on site, water use is dependent on the LANSCE run cycle.

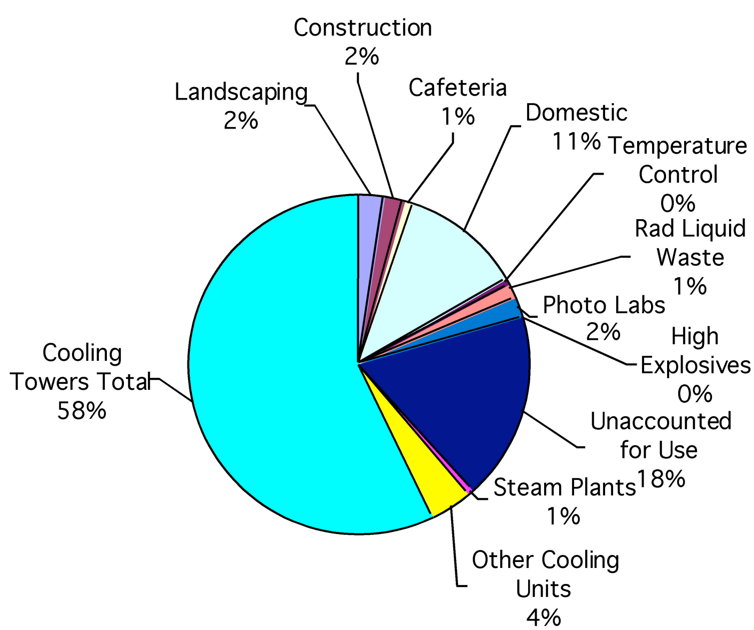


Fig. 7-2. FY97 Laboratory water usage.

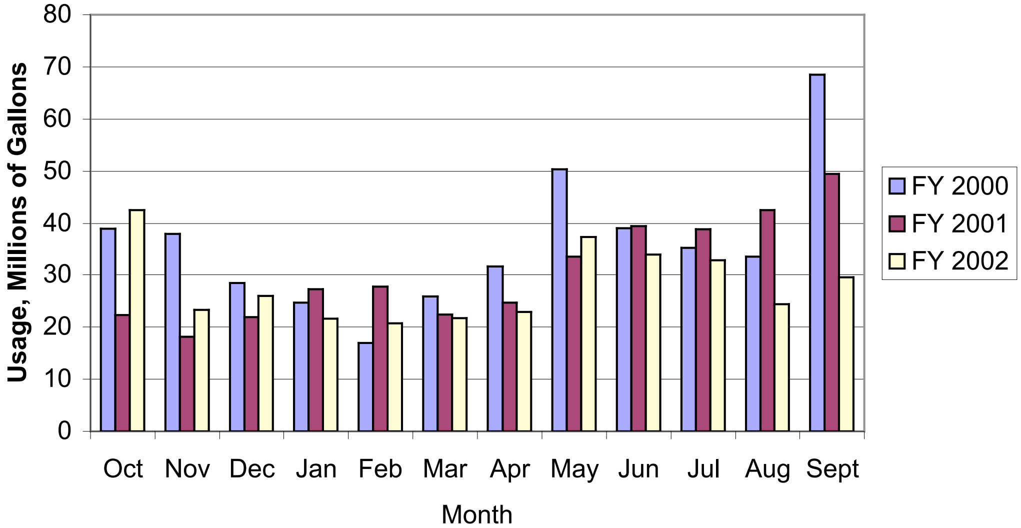


Fig. 7-3. Monthly water consumption.

Over the past few years, LANSCE run cycles have been shortened by comparison to previous years. Thus, a strong correlation between LANSCE-run energy consumption and overall water consumption is not immediately evident. However, when LANSCE resumes a full 7- to 9-month operation cycle, the effect on water consumption will be more pronounced.

7.2. Water Conservation Performance

The Laboratory has not established water conservation performance goals. However, Executive Order (EO) 13123, "Greening the Government through Energy Efficiency Management," mandates the development of such water goals. In advance of these goals, the Laboratory has committed to an aggressive water conservation program. The consumption of water at the Laboratory (by year) for recent years is shown in Fig. 7-4.

The data for years before 1999 are approximate because of many factors, including incomplete metering at the Laboratory, unknown system losses, and uncertainty in distribution. There are no reliable data for FY98 because in that year, operation of the Los Alamos water supply and distribution system was transferred from the DOE to Los Alamos County. The different techniques for measuring and estimating water used at these two entities lead to greater-than-normal uncertainty in the estimate of water use. There is no strong trend in water use at the Laboratory. A pronounced reduction occurred in the mid-1990s, but consumption then rose again. Consumption has decreased over the last 3 years, in part because of an aggressive leak repair program and attention to cooling-tower operations. LANSCE has installed new cooling towers and improved the cooling-tower control systems. These projects at LANSCE have reduced water consumption by several million gallons per year. The Nicholas Metropolis Center has been upgraded to modern, efficient cooling-tower control systems and is using Sanitary Wastewater System (SWS) water. Improved cooling-tower control systems have been installed at TA-35. The effect of these improvements has been to lower water consumption at the Laboratory markedly.

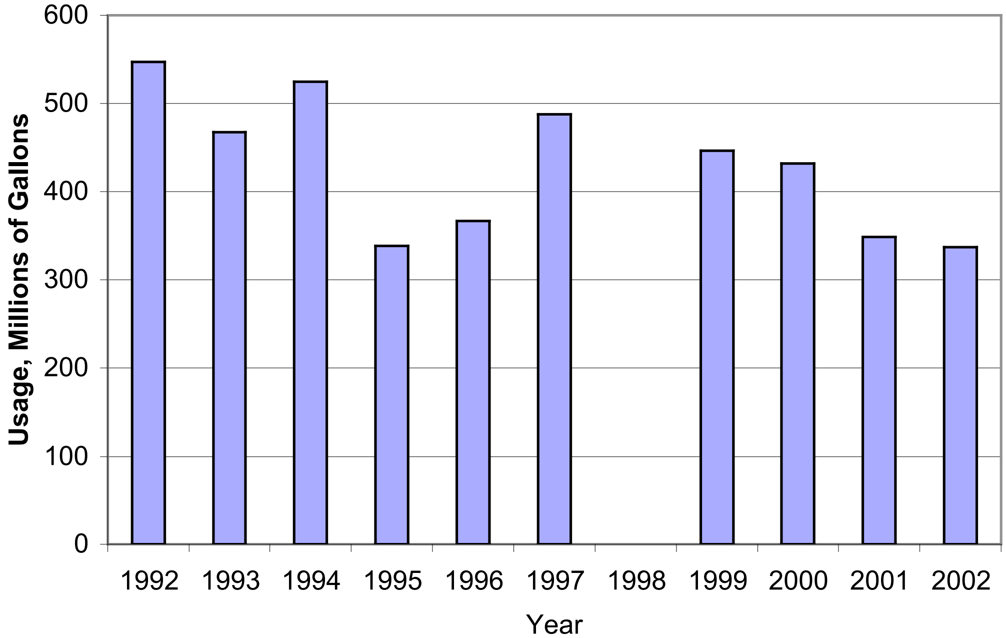


Fig. 7-4. Water usage by year.

Construction is underway on the Cooling-Tower Water Conservation (CTWC) Project and the TA-48 cooling-tower control systems upgrade. When these projects are finished, the Laboratory's consumption of water will be reduced a further 40 million gallons per year.

7.3. Waste Stream Analysis

Consumptive use of water leads to evaporation or discharge following use. At the Laboratory, NPDES and GW permits control most discharges of wastewater. Of all the water that comes onto the site, approximately half evaporates. That which does not evaporate eventually is discharged. Of the discharged water, 88% is regulated by NPDES/GW permits. The remaining 12% of discharges is not regulated. Figure 7-5 shows the distribution of water discharge and loss at the Laboratory.

The following wastewater streams are associated with water use at the Laboratory.

- Evaporation—Many water uses at the Laboratory involve some evaporation. Some uses, such as cooling towers, involve large losses through evaporation.

- NPDES-Regulated Discharges—These discharges originate from cooling towers, cafeterias, domestic use, research activities, laboratories, steam plants, etc. Much of this water is treated before discharge, either within the SWS plant or in a specialized treatment plant such as the High Explosives Wastewater Treatment Plant.

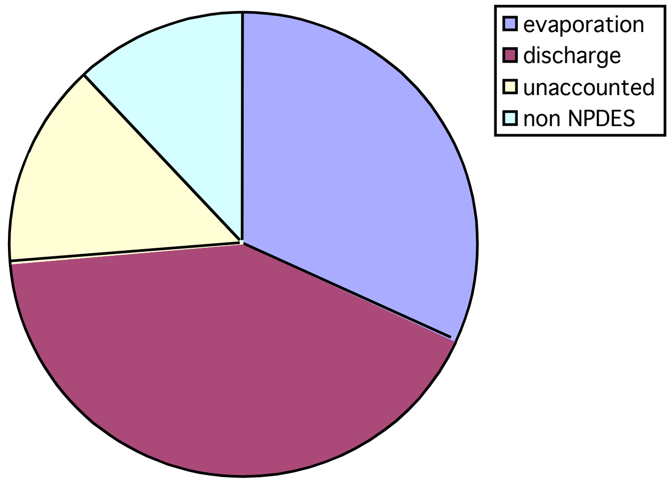


Fig. 7-5. Water discharge and losses.

- Non-NPDES-Regulated Discharges—These discharges occur through those activities exempted from the NPDES. They include discharges from landscaping and construction.

- Unaccounted Use—This waste stream is water that is drawn from the water supply but that either does not enter a Laboratory-consumptive-use process or is not accounted for in that use. The quantity of water drawn from wells is reasonably well known, and the water use at the Laboratory can be estimated. Usually, ~10% to 15% of the water drawn from the water supply cannot be accounted for. The sources of this apparent loss could be inaccuracies in the use estimates, leaks in the distribution system, or a combination of these and other uncertainties. With the current metering system, we find that it is not possible to estimate the size of this stream reliably or to find the source of the losses.

7.4. Improvement Projects

Several measures could be implemented to reduce the quantities of water used, improve the life of the aquifer, and reduce the environmental impact from water use. The projects, which are intended to reduce water consumption and increase the efficiency of use, are classified as completed, ongoing, or unfunded.

7.4.1. Completed Projects

LANSCE Cooling-Tower Control System Upgrades. LANSCE has three large cooling towers [two supporting LANSCE and one supporting the Low-Energy Demonstration Accelerator (LEDA)]. These towers operated at one to two cycles of concentration using ~110 million gallons of potable water yearly. Because this facility is geographically distant from the CTWC Project, it will not have access to the treated sanitary wastewater that would allow it to increase to 10 cycles of concentration. However, the LANSCE cooling towers have increased their cycles through better control systems. The facility personnel installed control systems on the three cooling towers in FY02 to achieve three cycles of concentration. This water conservation initiative will save 33 to 50 million gallons of potable water annually.

Upgrades to the Cooling-Tower Operations and Maintenance Manual and the Los Alamos National Laboratory Engineering Manual. The evaluation of the small-cooling-tower control systems at TA-35 and TA-48 helped determine which control systems were appropriate for the differently sized towers. The Prevention Program (PP) Office and FWO distributed this information throughout the Laboratory via the Cooling-Tower Operations and Maintenance Manual and the Los Alamos National Laboratory Engineering Manual. These two manuals require implementation of cooling-tower upgrades for all new cooling systems and for all large maintenance upgrades.

7.4.2. Ongoing and New FY02 Projects

CTWC Project. The CTWC Project, funded by the Infrastructure, Facilities, and Construction Office, is a $4.5 million program that was initiated to seek the best commercial technologies for improving cooling-tower-water use. The Laboratory issued a Request for Proposal (RFP) to industry to pilot water conservation technologies on large-scale cooling towers with both potable and treated sanitary wastewater. The pilot phase is complete, and the results have been evaluated. The Laboratory will construct a building containing water filtration/treatment process equipment. This equipment will remove particulates from treated sanitary wastewater in the sewage treatment plant at TA-46 for reuse in cooling towers at TA-3. The plant is expected to be on line in FY03. Phase I of the project will supply filtered water to the Nicholas Metropolis Center. Table 7-1 presents the amount of water used at the Laboratory with and without the treatment facility.

TABLE 7-1
LABORATORY WATER USE WITHOUT THE TREATMENT FACILITY (Mgal.[a]) (ASSUMES TWO CYCLES OF CONCENTRATION)

Cooling Tower	Current		FY03–04	
	Without Facility	With Facility	Without Facility	With Facility
Nicholas Metropolis Center	103	103	51	0
LANSCE	111	111	111	111
LEDA	21	21	21	21
LDCC/CCF	28	28	28	15
Power Plant 29-Mgal. Boiler Makeup 53-Mgal. Cooling Tower	82	82	82	82
General Usage	318	318	318	318
Total	663	663	611	547
With SWS Reuse	53	53	53	72
Total	610	610	558	475

[a]Mgal. = millions of gallons.

A water savings of this magnitude means that water to outfalls will be reduced. The FY03 phase of the CTWC Project reduces the water to the NPDES/GW-permitted outfalls to less than 20% and will have no impact on the wetlands supported by the outfalls. The wetlands impacts must be evaluated before Phase II implementation of the CTWC Project. Recent estimates are slightly different from those provided by the Laboratory Sitewide Environmental Impact Statement (SWEIS).[7-1] They are based on the most recent operating experience; however, it should be understood that the estimates provided in the SWEIS are the official projections.

Use of Treated Sanitary Wastewater in the Nicholas Metropolis Center Cooling Towers. The Nicholas Metropolis Center came online in January 2002. Because of the significant water required to cool the computers in this facility, the center has committed to using treated sanitary wastewater in the cooling towers. The center will not increase the Laboratory's net water use. After the CTWC Project comes on line, the Nicholas Metropolis Center will use filtered treated sanitary wastewater, thus improving the efficiencies of the cooling towers.

Use of Environmentally Beneficial Plantings. Environmentally beneficial and economical landscaping is required, where appropriate, by EO 13123. The Laboratory currently has no plans to replace existing plantings; however, the Engineering Manual requires that all new construction projects plant native vegetation landscaping. This project will not reduce current water usage but will limit future growth in water use.

Water Metering Project. The Laboratory has few water meters installed on facilities or systems. To better understand the water use at the Laboratory, the Water Metering Project is underway. This project will meter significant water users, such as large cooling towers. The project is ongoing and will not in itself save water, but it will allow more efficient management of water resources.

7.4.3. Unfunded Projects

Import Los Alamos County Waste Water. The TA-46 SWS plant is operating so far below design capacity that the digester microbes are vulnerable to starvation during holidays and to die-off from small quantities of toxic influents. Mildly toxic substances such as wax stripper in mop water and mop-water detergent currently cannot be sent to the SWS plant because of the microbes' vulnerability. Larger volumes of sanitary waste would reduce the vulnerabilities of the SWS plant. The Los Alamos County wastewater treatment plant is running at >80% capacity and is in danger of reaching full capacity in the near future. The transfer of Los Alamos County Western-Area residential wastewater to the Laboratory's wastewater plant would reduce that plant's vulnerability and provide an additional 65 million gallons per year of SWS effluent for reuse in the cooling towers. This project benefits both the County and the Laboratory. Two aspects of this project require funding: (1) modifying the Laboratory infrastructure to get the wastewater to the SWS plant and (2) upgrading the CTWC facility and its infrastructure to get the additional treated water to the cooling towers.

Survey and Repair Leaks in the Piping in the Water Drainage System. The Laboratory has conducted camera inspections of the 50 miles of sewer lines and has concluded that as much as 25% of the lines may be subject to leakage. No measurements have been taken to date of the losses to leakage from the sewer system.

Small-Cooling-Tower Upgrades Throughout the Site. The PP Office has funded cooling-tower control system upgrades for TA-35 and TA-48. Over 30 other small cooling towers at the Laboratory must be assessed and upgraded to increase water efficiencies. Implementing the new requirements in the Cooling-Tower Operation and Maintenance Manual and the Engineering Manual will be a step toward implementing these upgrades. Without funding, these manuals will be able to incorporate only the requirements on new cooling towers and on cooling towers undergoing major upgrades.

Water use at the Laboratory is projected to grow steadily over the next 5 years as either new capabilities come on line or existing capabilities are expanded. Increased electrical usage and the necessity to remove heat generated by the electricity largely will drive increased water consumption. The magnitude of the increased water use is uncertain, but the projects described in this section can act to reduce some water consumption. Figure 7-6 shows the impact of the proposed projects on the Laboratory's entire consumption of water in millions of gallons for FY05.

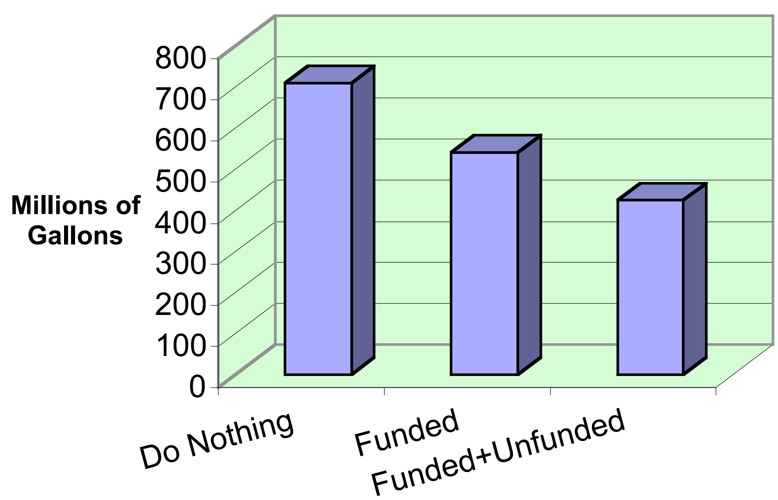


Fig. 7-6. Impact of proposed projects on the Laboratory's water consumption.

REFERENCES

7-1. "The Site Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory," Department of Energy report DOE/EIS-0238 (January 1999).

8.0. ENERGY USE AND CONSERVATION

8.1. Introduction

The continued growth of Los Alamos National Laboratory (the Laboratory) has required and will continue to require increased energy consumption. The addition of various facilities at the Laboratory, such as the Strategic Computing Complex (SCC) and the Dual Axis Radiographic Hydrotest (DARHT) second axis, has increased demand significantly. Future projects will dramatically increase the demand for electrical energy and for increased load-following capability.[8-1] Access to adequate, reliable power supplies is critical to the continued growth of the Laboratory and particularly to the ability to develop large experimental programs and computing facilities. The consumption of energy at the Laboratory clearly has reached the point where careful planning for the future will be required if growth is to be sustained. The Facility and Waste Operations Utilities and Infrastructure Group (FWO/UI) is responsible for energy planning and energy use management at the Laboratory. This group also is responsible for the Laboratory's energy conservation program.

The current power demand challenges the existing system capacity; thus, any future growth of the Laboratory depends on finding practical and cost-effective solutions to the electrical supply and usage problems. Two avenues for improving the energy supply are conservation and increases in power import or generation capability. Of these two options, conservation is the easiest to implement, will have more immediate results, and will minimize the impact of energy usage on the environment; however, increasing the supply will have a much larger effect on energy availability, as well as on the environment. The Laboratory has been addressing these problems for some time and has taken significant actions, including studying options to increase the power supply and implementing Laboratory-wide conservation programs. This section investigates the trends in energy use over time, examines the constraints on such usage, defines problem areas, and explores issues and options for improved performance.

The Laboratory power supply problems are exacerbated by regional and national situations. Regionally, the northern New Mexico power grid is operating near capacity. If demand increases much beyond current levels, some load shedding may be required across the entire grid. This means that the Los Alamos Power Pool (LAPP) could be required to shed its load by curtailing electrical use and shutting down operation in one or more facilities. Nationally, the available generating capacity has not kept pace with demand, which, coupled with deregulation, has led to volatility in electrical energy costs. Costs on the open market have dropped from ~$55/MWh to ~$25/MWh. If this trend persists, the cost of electrical energy could alter the strategy for ensuring future energy supplies. At the higher energy costs, a premium is placed on conservation and onsite generation. At lower energy costs, the purchase of offsite power to make up shortfalls is preferred.

The utility system (water, natural gas, and electricity supply) at the Laboratory is driven by the demand for electrical energy. As energy requirements go up, the demand for cooling water and the volume of effluent discharged at outfalls increase. Most of the Laboratory's consumption of electrical energy manifests itself as heat that must be removed and dissipated. In fact, ~60% of the Laboratory's water is used in cooling towers. Although the electrical supply can be increased by implementing one or more options, the critical component of the energy/water cycle (i.e., the availability of water) cannot easily be increased (see Section 7, Water Use and Conservation). The parameter most likely to limit Laboratory growth is the availability of water. Although the Laboratory currently is far from that limit, additional electrical demand brings the limit closer. Projected increased reliance on the power plant for load-following will have a pronounced effect on water use at the Laboratory. The Technical Area (TA)-3 power plant most often is used as a power-peaking facility. The facility is aging and is inefficient by modern standards; therefore, its water consumption is large relative to the energy it produces.

The system diagram for the Laboratory's consumption of energy and water is shown in Fig. 8-1.

Laboratory operation requires the consumption of water, natural gas, and electricity. Air emissions and effluent discharges result from this consumption. The use of energy and water at the Laboratory is closely coupled. Therefore, the electrical supply system at the Laboratory will be analyzed in this section.

The largest users of electrical energy at the Laboratory are shown in Table 8-1. The top four consumers account for up to 51 MW at coincidental peaks.

The peak electrical demand tends to be seasonal but nearly always is greatest when the Los Alamos Neutron Science Center Experiment (LANSCE) is operating. The peak demand for the last 2 years is shown in Fig. 8-2.

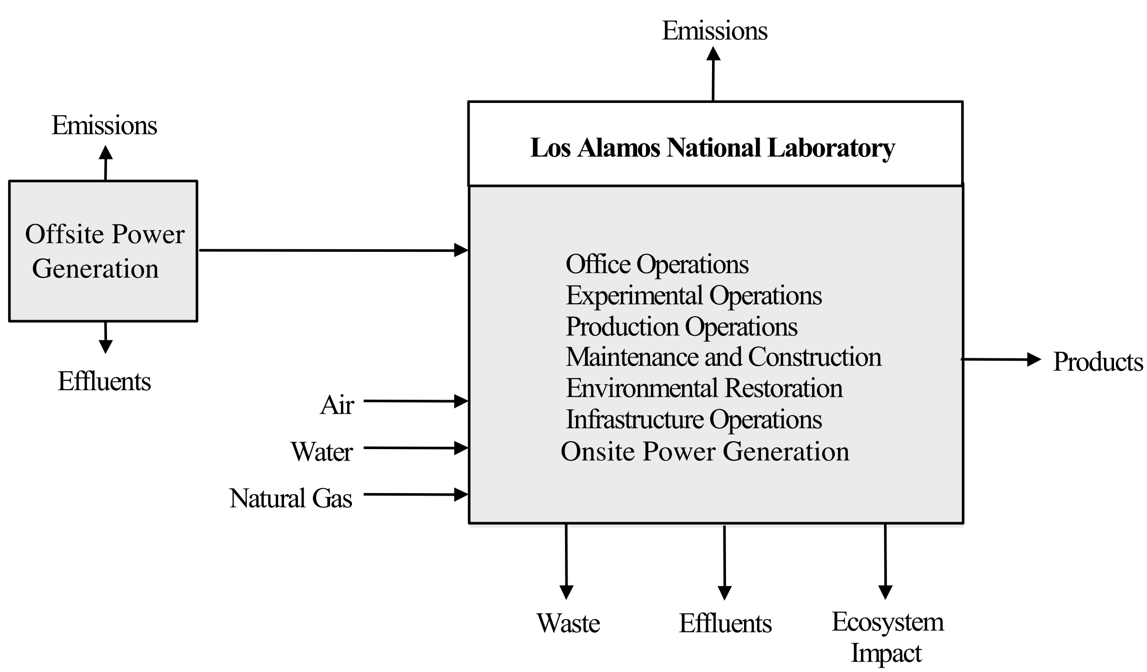


Fig. 8-1. Energy process map for the Laboratory.

TABLE 8-1
ELECTRICAL ENERGY USAGE AT THE LABORATORY

Facility	Electrical Load (MW)	Duration
LANSCE—peak demand	25–32	24 h/d during operation
LANSCE—base load	5–7	24 h/d
Nicholas Metropolis Center (SCC)	3–5	24 h/d
Computing (CCF[a] and LDCC[b])	4–5	24 h/d
TA-3[c]	10	5 d/week
TA-55	2–3	24 h/d

[a]Central Computing Facility.
[b]Laboratory Data Communications Center.
[c]The above total for Technical Area (TA)-3 does not include the 5 MW for the LDCC/CCF. Computing at TA-3 is separate. A 10-MW, Laboratory-wide peak load swing occurs during weekends and holidays.

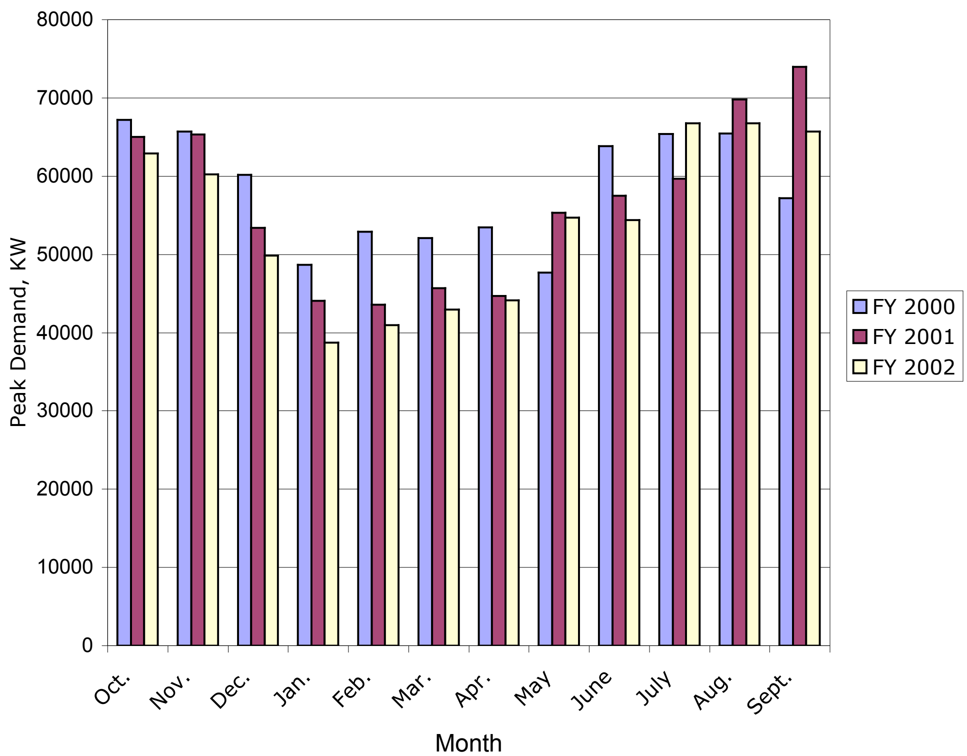


Fig. 8-2. Peak electrical demand.

The peak demand is important in planning for electrical supply because the LAPP has a firm load-serving capability that is limited to 82 MW. The portion of the LAPP power supply that relies on regional hydropower is seasonal and during the winter months falls to zero. If the load demand exceeds the load-serving capability, onsite generation is required to make up the deficit. If the LAPP power supply is inadequate for the load demand, LAPP can either buy power on the open market or generate additional power on site. The limitations and options for a power supply are critical to the long-term power supply planning process and also may influence the dispatch of power on an hourly basis.

The monthly consumption of electricity at the Laboratory for the past 2 years is shown in Fig. 8-3. It is interesting to note that although the monthly peak demand has decreased from last year, the total Laboratory electrical usage increased significantly in fiscal year (FY)02. This decrease in demand coupled with increased total usage comes from load management. In particular, LANSCE has adjusted its load so that the LANSCE peak demand is not coincident with the Laboratory's base-infrastructure peak-demand period. Shifting loads to off-peak hours has reduced the daily peak demand.

The data shown in Fig. 8-3 include the LANSCE usage. The Laboratory's usage without LANSCE is shown in Fig. 8-4.

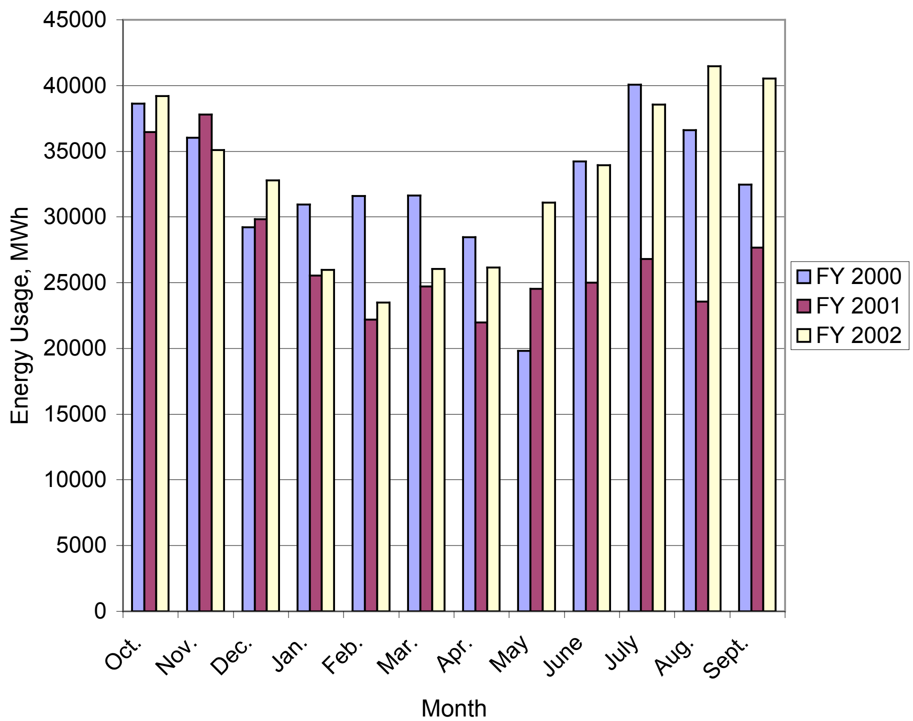


Fig. 8-3. The Laboratory's energy usage.

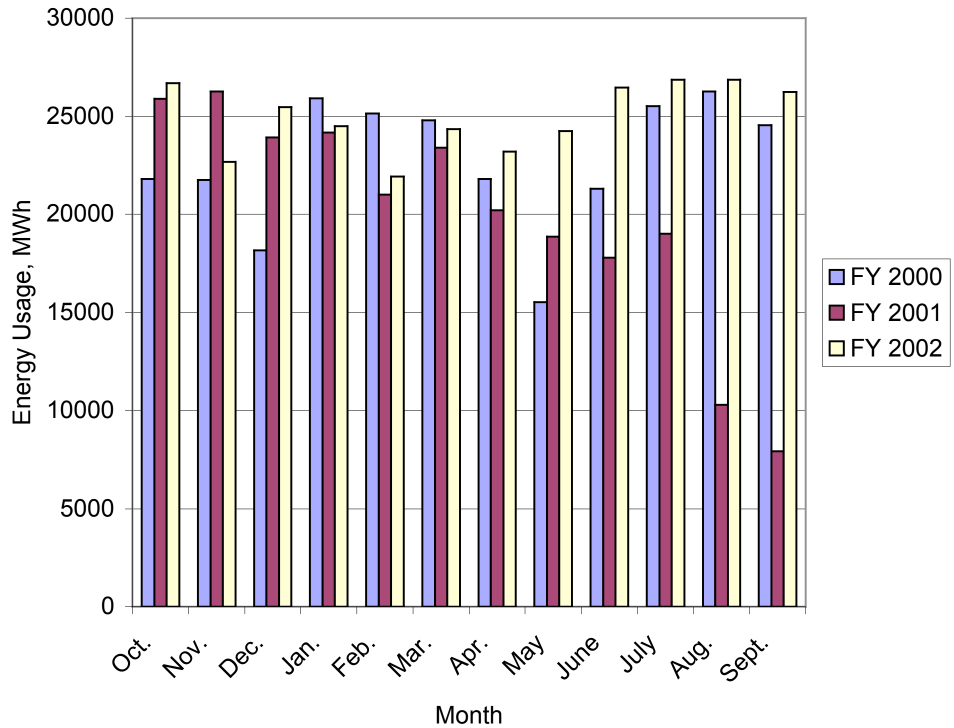


Fig. 8-4. The Laboratory's energy usage without LANSCE.

8.2. Energy Conservation Performance

Energy usage is not regulated, but the government has established guidelines for government facilities in the *Energy Policy Act of 1992* and in Executive Order (EO) 12902, *Energy Efficiency and Water Conservation at Federal Facilities* (March 8, 1994). EO 12902 mandates a 30% reduction in energy use for agencies by FY05 as compared with FY85.

Utility loads associated with the operations of LANSCE (defined as experimental processes) are excluded from this measure. The measure is based on a reduction in energy usage from FY85 levels in British thermal units per gross square feet of building, expressed as a percentage of FY85 energy usage. The total energy includes electricity, natural gas, and liquefied petroleum gas. The Laboratory includes electricity, natural gas, and liquefied petroleum gas. The available data for energy consumption do not allow the reliable estimation of consumption by division or by user other than the largest users, nor does the performance measure require it. Therefore, there is no detailed breakdown of consumption for energy.

Laboratory electrical consumption is shown by year in Fig. 8-5.

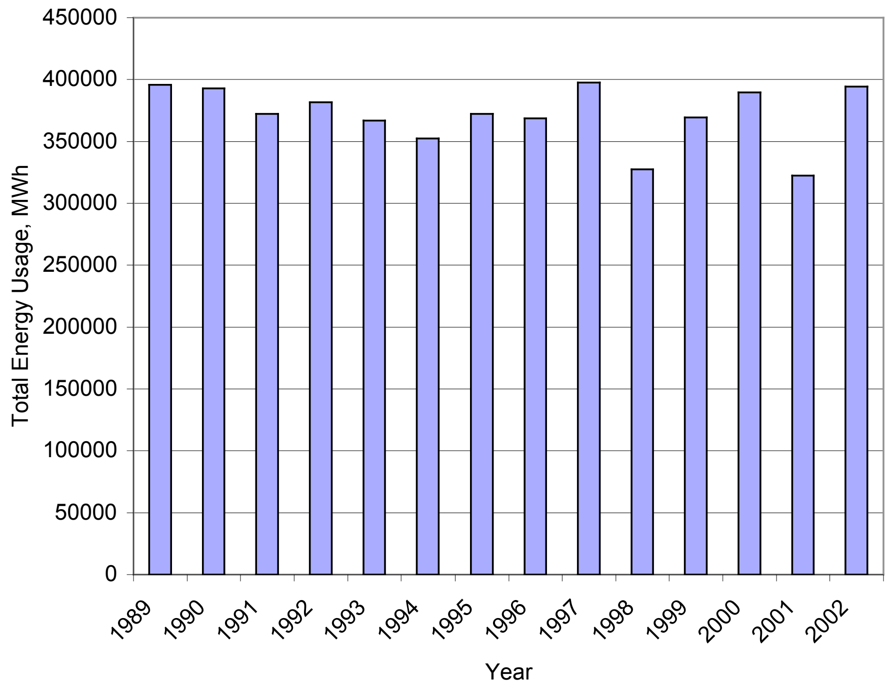


Fig. 8-5. The Laboratory's electrical usage.

The Laboratory's use of natural gas is limited and tends to be seasonal. The principal use of natural gas is for space heating, although natural gas is burned by the power plant. Natural gas usage is shown for the last two FYs in Fig. 8-6.

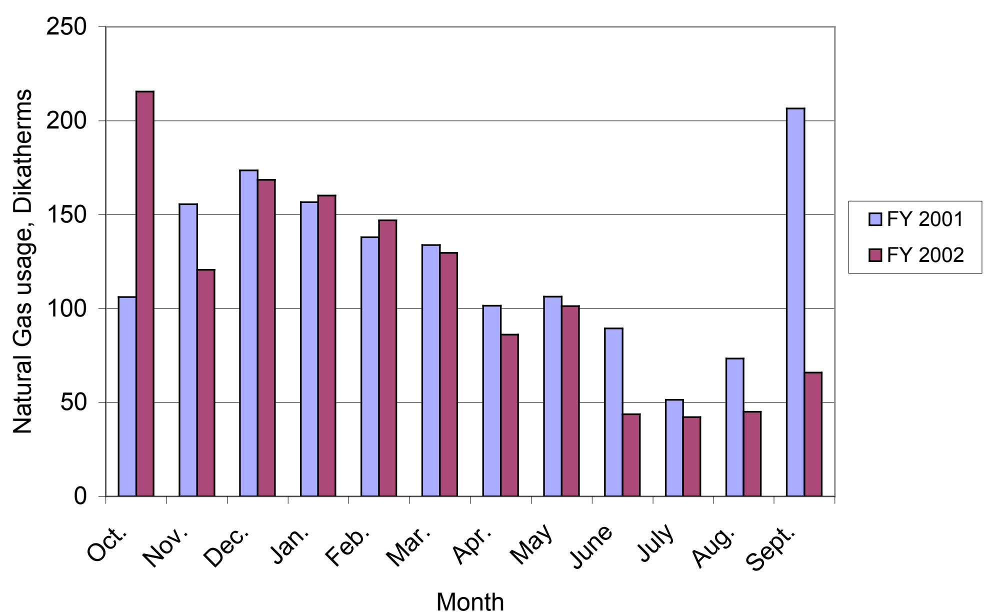


Fig. 8-6. Natural gas consumption at the Laboratory.

8.3. Waste Stream Analysis

The impact of the electricity usage by the Laboratory is at least regional and arguably global. Regional coal and water resources are affected by the necessity to generate power for the Laboratory, and emissions from this generation of power, which although are small in an absolute sense, nevertheless contribute to pollution of the global atmosphere. The Laboratory cannot function with a significant reduction in electrical usage; in fact, the Laboratory will require more electrical power in the future. The increased usage of power directly impacts not only the waste streams associated with power generation, but also water consumption and wastewater discharge. Usage of electricity is a complex system at the Laboratory and is strongly coupled to the consumption of water and emission of pollutants.

Electricity is imported into the Laboratory from offsite sources; however, because peak coincidental demand can exceed the import capacity, it sometimes is necessary to generate power at TA-3 by burning fuel oil or natural gas. Natural gas also is burned to produce steam and hot water for space heating and process support.

The waste streams associated with use of energy at the Laboratory are emissions in the form of industrial gases and wastewater effluent from various cooling towers. Emissions occur on site when the TA-3 power plant is operating and as the result of Laboratory consumption of electricity imported from off site. Emergency power generation and portable generators also produce emissions. The process map element for energy use is shown in Fig. 8-1.

With the exception of water usage in conjunction with onsite generation, the sizes of the waste streams associated with Laboratory electrical usage are not known.

8.4. Improvement Projects

The following projects were identified as potential measures for improving the energy generation, import, conservation, distribution, and reliability at the Laboratory. These projects are divided into three categories: (1) projects completed in the last year, (2) projects currently funded and ongoing, and (3) unfunded proposed projects.

8.4.1. Completed Projects

These projects have been completed and/or implemented in the last year.

Western Technical Area (WTA) Substation Enhancement. A new substation was put into service at the WTA site. The transformer has a maximum capacity of ~56 MW. The new substation serves to offload the TA-3 substation by providing express feed to the SCC, S Site, and other facilities now served by the TA-3 substation. The new substation also provides redundancy against loss of the TA-3 substation.

Power Plant Motor Control and Emergency Generator Upgrades. The existing power plant motor control center was upgraded, and a new, higher-powered, 1.1-MW emergency power generator was installed.

Stack Gas Recirculation System at the Power Plant. A stack gas recirculation system was added to the power plant. This addition will improve efficiency and reduce the emission of criteria industrial gases.

8.4.2. Ongoing Projects

These projects have been funded and currently are being executed.

Chiller Replacement. An increase in efficiency will be realized when the older chillers around the Laboratory are replaced with modern and more efficient chillers. Some of the chillers at TA-3 already have been replaced, and the program will continue in the future. A sitewide chiller upgrade will save up to 1.5 MW of energy.

Conservation. An operational incentive is in place to conserve electricity. As much as 72 to 168 MWh of usage could be avoided by implementing simple conservation measures such as "Energy Star" computing. For that reason, the Laboratory has had a conservation program in place for some time.[8-2] Significant savings have been realized as a result of this program. Further savings will be realized, without additional cost, through projects already planned. The LANSCE 201-MHz upgrade will result in a savings of ~1 MW. Although conservation can never solve the peak-demand problem completely, these measures may be a very effective, short-term remedy. A reduction in demand through conservation will mean that near-term growth will not challenge the firm load-serving capability of offsite import and will reduce the frequency of TA-3 power plant operation. The power plant is a particularly inefficient power producer, and its use has been increasing in response to the growth of peak coincidental demand. It may be possible to save as much as 10 MW through combined conservation efforts.

Combustion Turbine Procurement. The Laboratory has begun the process of procuring a 20-MW, simple-cycle, gas-fired turbine for onsite power generation. The Laboratory has received a proposal as a result of a request for proposal (RFP) issued this FY. The project is expected to enter Title Two design in FY02, with a turbine in place at TA-3, Building 22 in FY04.

Expanded Metering. Numerous meters have been installed at the largest energy consuming facilities, and the meter installation program is continuing. The installation of meters allows better reporting and analysis of energy data.

8.4.3. Proposed Projects

These projects or actions have been proposed to allow further increases in efficiency and reliability. Some currently are unfunded. If implemented, they will provide an additional margin against unexpected and unplanned increases in energy consumption.

Continued Chiller Replacement. Chiller replacement is underway for a significant number of chillers at the Laboratory. However, although many sites are candidates for replacement, no funding is available. The replacement of the chillers at LANSCE would have a significant effect on electrical usage, as would the replacement of chillers at TA-48 and the balance of TA-3. Funding has not been identified for these projects. Modern chillers are twice as efficient as the older chillers; thus, the use of modern chillers represents a significant savings.

Additional Turbine Refurbishment. The Laboratory will perform a study to establish the cost and feasibility of refurbishing another turbine at the power plant. If feasibility and acceptable costs are established, a plan and schedule for the work will be developed.

The existing data and the volatile nature of energy consumption at the Laboratory do not allow reliable comparison of FY05 projected consumption with and without conservation project implementation. However, the implementation of the above projects will reduce peak demand by a minimum of 21 MW.

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8-1. M. Hinrichs and J. Lundberg, "Approaches for Upgrading Electrical Power System Reliability and Import Capability," Los Alamos National Laboratory report LA-UR-96-3882 (August 1997).

8-2. E. Racinez, "Energy Management Plan for Los Alamos National Laboratory, Los Alamos, New Mexico," Rogers and Associates report (December 27, 1996).